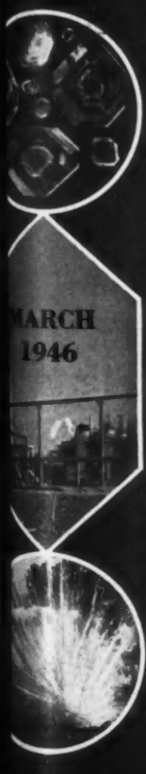
Read Who Will Be Who?

CHEMISTRY



ARTICLES YOU CAN UNDERSTAND

25¢

★ A SCIENCE SERVICE PUBLICATION ★

Understanding

➤ As clouds of secrecy roll away, which recently obscured war-time advances in science, it becomes more and more necessary for the interested layman to run at top speed in order to stay in the same place. How can he understand all the new developments?

What does one mean by understanding science? Obviously, something new learned must connect in the mind with something already established there. That is the basis for the historical approach to teaching chemistry. Recognition of oxygen, nitrogen and carbon dioxide gives a chemical interpretation to familiar experiences and leads the student on into less familiar territory.

But the constitution of air and the phenomena of combustion were news two hundred years ago, and a lot of things have happened since then. Laws of combination and valence, the Periodic Table, ionization, the carbon compounds, methods of analysis and synthesis, the use of catalysts, radioactivity, the Phase Rule, techniques of colloidal chemistry and plastics, silicones, the structure of the atom and its consequences are some of the high points that come readily to mind. How much of these do you have to know?

Well—there is no law that says you *have* to learn anything (except, perhaps, the law of the survival of the fittest, in a technical age). If you find the discovery of new facts the most exciting thing in the world, you will eagerly join each new discovery to what you knew previously, and enjoy filling the gaps between.

A case in point is the now-historic Smyth Report. Reactions to it have run the whole gamut. In our personal experience, there was the teacher who made the flat statement, "Nobody can understand the Smyth Report." Then there was the group of boys who devoured the volume so avidly that one of them, reminded that he had a train to catch, merely waved us away with the remark, "There are other trains." What a tragedy when such a pupil draws such a teacher!

CHEMISTRY

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CAN WE TELL *whether this future-eyed young scientist will make his mark in research?* WWWWX

Who Will Be Who In Science?

This is a working memorandum for a committee studying the problem of the recognition of talent in our schools. Written by Watson Davis, it is printed here without prejudice to that committee because its content illumines the Science Talent Search essays in this and the next issue of CHEMISTRY. See page, 8 for this months installment of these essays. Incidentally, the young bacteriologist in the photograph is a member of the Kramer Junior High School Science Club, Washington, D. C. He is absorbed in his experiment and young Walter Shropshire is, we are sure, more interested in what he is doing than what the future holds and what educators are discussing.

IN OUR attempt to pick out from the thousands of boys and girls in school those "who will be who" in scientific research, we are faced with the difficulty in this field, as to a more or less degree in all other fields, that we do not know exactly what we are looking for.

We are attempting to select those who have some likelihood of being the scientists of tomorrow. Yet we cannot write a formula for a great scientist, and say, positively, this is it, this is scientific genius or scientific ability of a high order.

We may observe great scientists,

study their lives and deeds, to determine what makes them the way they are. This has not been done with sufficient intensity or seriousness. We have not quite dared to ask the galaxy of Nobelists in our country, for instance, to take the science aptitude examination used in the Science Talent Search conducted by Science Service, to see how they, of proved ability, would do on it—or rather how well the examination would do when put to this test.

Yet we are confident that until we can isolate the various and complex elements in human ability, as Dr. L. L. Thurstone of the University of Chicago is proceeding to do with so much promise, the general techniques that are being used are effective and useful.

If we but know what to look for and how to expose it to observation, scientific talent or ability can be spotted in the very young, just as an ability to do things with one's hands, manual dexterity, may be noticed.

The omnipresent childish "why?" in the intellectually advanced may not be a sure sign, but a nursery school child who solves problems for himself by trial and error to an unusual degree will bear watching. At a later age in the grades, the collector of rocks from the playground or beetles from the garden may be showing the beginning of a great biologist. The child who starts making or working with things for himself in the cellar or garage may be a physicist, chemist or engineer of the future. An unconventionality of approach would be more exciting than slavish imitation of companions or elders, in these cases. Trying what mother and father indicate by their attitudes they have not done would probably be a good sign. Playing or working with chemistry sets, or radios, or other such experimental materials, have almost always been episodes in the childhoods of great scientists of today.

There are some capable of being scientists of the future who do not have the opportunity to come into contact with science in any effective way. They may be in an essentially primitive and non-science environment or home situation, in this country or abroad, or they may be handicapped by an inferior school system which does little more than rote learning. These boys and girls present a special problem which comparatively may not be a major one, but the selection techniques should be geared to pick even those of innate ability who do not have the usual opportunities.

An alert and competent teacher, interested in science, will be able to single out from the crowd these boys and girls who demonstrate their ability and interest in science. How consistently the student of scientific research potentialities can be nurtured and aided, year by year, depends upon the carryover in the educational system. A teacher interested in science may be followed by a teacher disinterested or hostile to science. The establishment of a dossier on each student, which would follow him through school like a birth certificate, vaccination or health record, has been suggested as a remedy. In this there is the same problem that is created by the passing on year by year of scholastic and IQ records, or, in the adult sphere, the use of black or white lists and the establishment of records within investigational organizations that are al-

➤DR. GLENN T. SEABORG, *co-discoverer of plutonium and chemical elements 95 and 96, explains the principle of transmutation to the young physicists and chemists attending the Fifth Science Talent Search Institute in Washington March 1 - 5, 1946.*

most impossible to change or counteract.

Consideration might be given to some mechanism for following, from outside the particular school, those who seem to have science talent at an early age. This would correspond to a science talent search of those who are, say, 10 years of age, which would highlight those selected for special attention, with due regard that they are not spoiled by undue attention.

The suggested continued observation of the scientific interest, attitudes and accomplishments of the boy or girl is probably the most effective method of discovering science talent at a relatively early age. Eventually, when the psychological and human ingredients of the various sorts of scientific ability are differentiated it may be possible to use tests for this purpose. It may even be possible to use a scientific aptitude test of relative simplicity for this purpose at the present state of our knowledge.

The recommendation blank filled out by teachers in the Science Service Science Talent Search has questions about scientific attitude that may be suggestive as to what to watch for. These questions are:

What has this student done to demonstrate his scientific attitude? Has he designed an experiment by himself? Does he "jump to conclusions"? Is he objective about most situations or does he react emotionally? Does he discriminate between pertinent and nonpertinent evidence in solving a problem? Does he "try it and see"?

Attention must be given to personality and psychiatric factors as they influence scientific ability. This is a field in which there must be more inquiry. Very brilliant young people who appear to be outstanding scholastically may become schizophrenic. Other personality disorders may develop. While successful scientists do not always have completely untroubled personalities, too great extremes in personality are in most cases barriers to success in scientific research as in other activities.

There should be increased opportunities at all educational levels for experience and study in science. Many of the fundamentals of science can be presented with understanding at a much earlier grade than is now the practice. It took many centuries for man to discover that he is one of the animals on one of the planets of a rather ordinary star in one of millions of galaxies. It took many centuries for him to learn to use fire, extract metals from the earth, grow his food, and finally develop the economic, industrial and scientific complexity that now exists. The child can recapitulate the first few thousands of years by the time he gets into the first few grades, if he is given the chance. Then he can catch up with the more detailed and complex aspects of science, pure and applied, so that at the age of 15 to 17 he can be well begun on his own researches in science, if he has it in him.

For the scientifically talented child, the formal science classes are not enough. For him the science club is often a means of forging ahead faster than the average of the science classes, working with others who are scientifically talented. Science clubs in this aspect play an important role in development of science talent. This is an added reason for the organization in each school of one or more science clubs.

For the past five years Science Service through Science Clubs of America, its national science clubs organization, has conducted the annual Science Talent Search for the Westinghouse science scholarships. Each year all interested in science in the nation's secondary school senior classes are invited to enter this contest. About 15,000 examination blanks are distributed, and about 3,000 are returned as completed entries. Of these 300 are picked for honors, with 40 declared winners, invited to a 5-day institute in Washington and given scholarship recognition. The other 260 are given honorable mention and recommended to colleges as suitable for scholarships.

The selection technique used involves a science aptitude examination, a personal data blank, a teacher's recommendation form, a scholarship record, and an essay on "My Scientific Project."

‣ Dr. Lise Meitner, *visiting professor at Catholic University of America, who first recognized the implications of atomic fission, discusses atomic phenomena with a group of Fifth S.T.S. winners.*

Those who made complete entries cleared the first hurdle.

The scores on the science aptitude examination constituted the second hurdle or selector. The top third of the contestants were selected according to scores on the three-hour-time-limit examination consisting of about a hundred questions. The first part of the science aptitude examination was composed of scientific problems with multiple choice answers. The second part consisted of paragraph reading tests on materials from various fields of science. A short third part was made up of questions reflecting judgment and breadth of scientific reading.

The academic records provided the third hurdle, based on a score obtained by weighing 5 to 1 the relative rank in high school class and units of high-school science taken. This selection reduced the number to somewhat more than 600.

Then the recommendations made by faculty members come into play.

➤ **Dr. E. U. Condon**, *Director of the U.S. Bureau of Standards, congratulates Jules Kernen and Marilyn Rohrer on their winning the boy's and girl's four-year Westinghouse scholarships, and Stephen Arnold and Josephine Raskind, their alternates, at the final banquet of the Fifth Science Talent Search. Watson Davis, Director of Science Service, who presided, looks on.*

Scored on the basis of actual accomplishments this hurdle brings the number down to slightly more than the 300 who will be given honors.

In all this selection process essentially two independent contests are being handled as the boys do not compete against the girls. The numbers in the final and intermediate selection are pre-determined by the arrangement that the honors would be divided among boys and girls in the ratio that boys and girls completed entries. Approximately one-quarter of the contestants and winners have been girls each year.

Essays are then introduced in the further selection process. Of course, each time an elimination is made, the whole record of each person involved, so far as it has been used, is considered.

The essays in one sense are the most revealing of the materials submitted, but they are the most difficult to evaluate from the standpoint of obtaining judgments and because of the time needed. They are read by three Science Service staff members, with good agreement of judgments.

When the 40 finalists in the Science Talent Search come to Washington, they are given 15-minute interviews by three or four judges, one of whom is a psychiatrist and two of whom are the psychologists who have devised the tests and made the previous judgments.

This selection technique is not perfect and it has been and should continue to be bettered as experience dictates. All entries in the First and Second Science Talent Searches are being followed to determine over a period of years whether those selected become to a greater degree productive and creative scientists. We do know that many of those selected have made outstanding college records and are beginning research careers. We do know that the methods and example of the Science Talent Search have stimulated to an extraordinary degree the nation's interest in finding and nurturing the young people who have science talent of potential use to the nation.

Much more needs to be done, and much of the progress to be made in the future must be at the classroom level through the understanding and intelligent endeavors of the science teachers and their associates in the educational system. There is a major place in the whole science educational effort for the city-wide and state-wide stimulation of science clubs through science fairs, science congresses, and other cooperative projects in which all science students in all grades of at least the junior and senior high schools can participate. In this effort there can and should be national cooperation of scientists, college educators and industrialists. The problems of the colleges in this field will be made simpler if the foundations in secondary schools are well built.

Young Chemists Compete

▸ ESSAYS on their projects in chemical fields, submitted as part of their entries in the Fifth Science Talent Search just completed, fill the next dozen pages of this issue of CHEMISTRY. Plastics, organic chemicals, pigments and unusual compounds inspired these high school boys and girls to try out, in home and school laboratories, methods of learning their properties. Top honors this year went to biologists. E. Marilyn Rohrer, 17, of the Elizabethtown, Pa., High School, won the four-year scholarship for girls. She wrote on the use of pentothal sodium as an anaesthetic, and brought as her exhibit a collection of the brains of various animals. (It was inevitable that she was nicknamed "the girl with the brains"). Boy winner was Jules Alfred Kernen, 16, of Southwest High School, St. Louis, Mo. who has made nutritional studies of white rats and wants to do research on cancer. For his project he made an ecological survey of a vacant lot near his home, cataloguing 245 varieties of plants and animals.

➤ Various classes *of plastics and their relation to the casein derivatives she worked with make up the exhibit arranged by Joan Lines.*

Casein Plastics

by Joan Louise Lines, 17
Nottingham High School, Syracuse, N. Y.

➤ The plastics industry had its beginnings in the discovery of nitro-cellulose by Alexander Parkes in 1864. Mankind, however, has been utilizing plastic materials since the birth of civilization—mud to fill cracks in caves and to make pottery, melted pitch to seal the jars in Egyptian tombs. A plastic is a substance which assumes a new shape under the influence of applied pressure and retains that shape when the pressure is removed. There are two main classes of plastics: thermoplastic and thermo-setting. The thermoplastics are compounds which may be deformed under the influence of heat and pressure, may be resoftened by heat and then remolded. Included in this class are casein plastics, as are all other chain plastics—those normally formed by polymerization. The thermo-setting materials are compounds which may be deformed

by heat and pressure, but the action is irreversible, since a chemical change takes place during heating. These plastics have a rigid molecular structure.

Casein plastic was first introduced in Germany by Spitteler and Krische around 1900 and given the name "Galalith" (milk-stone). A non-inflammable plastic with an unlimited color range, it is commercially known in this country as Ameroid and Galorn. Although easily machined and polished, the hygroscopicity of casein plastic has proved to be a drawback. Large pieces tend to warp; when uneven pieces are hardened in formaldehyde, the thin parts harden more quickly, setting up internal strains and stresses. Although hardened casein plastic can be sawed and cut, the tools must be operated slowly because of the plastic's poor heat conductivity.

Casein may be prepared in the laboratory by the Hammarsten acid precipitation of separated milk using dilute acetic acid. The precipitate is washed, dissolved in dilute ammonia, filtered, and reprecipitated with acetic acid. Pure casein is a white amorphous powder, insoluble in water, and having no taste or odor. The powder is gelatinized and hardened in formaldehyde, this reaction being the most important in the preparation of casein plastics. Last summer I prepared a small amount of casein in a manner somewhat similar to the above. I precipitated the casein from the separated milk with acetic acid, filtered the solution, and dried the precipitate. The powder was then mixed with a sufficient amount of very dilute formaldehyde to produce a highly cohesive mass. A ball of this, approximately an inch in diameter, was placed in formaldehyde and left to harden.

In the commercial preparation of casein plastics, the pure casein powder is gelatinized to a water percentage of 30-40%, then extruded from screw-type molds in the form of rods which may be pressed in heated hydraulic presses to form sheets. The plastic is then hardened in a 4-5% solution of formaldehyde, seasoned, dried, and straightened. Originally this hardening and seasoning process took weeks or even months, but the present process has been greatly speeded up by the addition of 2% alum to the casein mixture. My one-inch ball of non-alum casein has been in the hardening process for over six months. At the present time it has hardened considerably, but is still soft enough to be easily crushed or broken.

The extruded alum-casein rods are placed in an automatic screw machine or sliced into disc-shaped blanks which require only a few days to harden. The product is then smoothed by washing with water and pumice, glazed with a hypochlorite bath treatment (150° F, 2-5 minutes, rinsed and dried. Buttons, buckles, game counters, novelties and various accessories can be made very efficiently in this manner.

The chemical actions involved in the production of casein plastic are very complex. In fact, comparatively little is positively known of the manner in which the complicated protein groups react. The X-ray confirms the peptide linkage of amino acids and also suggests two types of protein structure—

fibrous and globular. The difference lies in the inter-reaction of the side chains of the latter which tend to pull the normally linear fibers into tangled bundles. Some scientists believe that the formaldehyde reacts with the amino acid group to yield a methylol structure by the elimination of water between the amino group and the hydroxyl group of formaldehyde reacting as methylene glycol.

$$\begin{array}{l} \mathrm{NH}\ \boxed{\mathrm{H}\qquad\quad \mathrm{OH}}\ \mathrm{CH_2\cdot OH} \\ \ \ | \\ \mathrm{CH_2\cdot COOH} \end{array} \rightarrow \begin{array}{l} \mathrm{NH\cdot CH_2\cdot OH} \\ \ \ | \\ \mathrm{CH_2\cdot COOH} \end{array}$$

Fleck represents the casein molecule as a polypeptide chain:

$$\begin{array}{cccccccccccc} & \mathrm{R} & & & \mathrm{R} & & & \mathrm{R} & & & \mathrm{R} & \\ & | & & & | & & & | & & & | & \\ \mathrm{-NH-} & \mathrm{CH} & \mathrm{-CO-} & \mathrm{NH-} & \mathrm{CH} & \mathrm{-CO-} & \mathrm{NH-} & \mathrm{CH} & \mathrm{-CO-} & \mathrm{NH-} & \mathrm{CH} & \mathrm{-CO-} \end{array}$$

in which R represents the side chains. The following chain combines the amino groups lysine, valine, and cystine.

$$\begin{array}{lllllll} & \mathrm{(CH_2)_4NH_2} & & \mathrm{CH_3} & & \mathrm{CH_2\cdot S\cdot S\cdot CH_2\cdot CH(NH_2)\cdot} & \\ & | & & | & & | & \mathrm{COOH} \\ \mathrm{-NH-} & \mathrm{CH} & \mathrm{-CO-NH-} & \mathrm{CH} & \mathrm{-CO-NH-} & \mathrm{CH-CO-} & \end{array}$$

According to Bowes and Pleass, formaldehyde combines with side chain amino groups and not with the amino-amide groups taking part in the linkage of the polypeptide chain. Astbury has shown by X-ray diffraction technique that the polypeptide chains are probably held together by secondary valencies in a sort of micelle arrangement with the side chains (R) projecting at right angles to the backbone on both sides.

$$\begin{array}{c} \mathrm{-NH-CH(R)-CO-NH-CH(R)-CO-NH-CH(R)-CO-} \\ \vdots \\ \mathrm{-CO-CH(R)-NH-CO-CH(R)-NH-CO-CH(R)-NH-} \\ \vdots \\ \mathrm{-NH-CH(R)-CO-NH-CH(R)-CO-NH-CH(R)-CO-} \end{array}$$

It has been shown by X-ray diffraction that casein treated with formaldehyde has similar diffraction spacings to alkaline para-formaldehyde (a solid white polymer made by slowly evaporating an aqueous solution of formaldehyde). Redfarn suggests that in formalized casein the formaldehyde is packed in the side chain space as para-formaldehyde and that the ends of the para-formaldehyde molecules are combined with side chain amino groups. Since one of the main constituents of para-formaldehyde is polyoxymethylene, the following reaction would occur.

$$\begin{array}{c} \mathrm{-NH_2 + HO\cdot CH_2O(CH_2O)_n\cdot CH_2OH + H_2N-} \rightarrow \\ \mathrm{-NH\cdot CH_2O(CH_2O)_n\cdot CH_2NH- + 2H_2O} \end{array}$$

If formaldehyde combines with the amino groups in a methylol arrangement, then it should be possible to deformalize casein completely. This has not been done experimentally, and probably some dehydration of methylol groups to

methylene groups occurs, although from investigation of the reaction of formaldehyde on the amino acids lysine, arginine and histidine, some researchers feel reasonably sure that the methylene linkage, $-N{=}CH$, is not present. Cross linkages are probable. Casein plastics are inclined to be resin-like and brittle, a characteristic of polymers having cross linkages.

The product of the protein-formaldehyde reaction has not proved too satisfactory. True, it has one of the widest color ranges in the field of plastics, but its hygroscopicity, length of seasoning, un-moldability, and brittleness tend to limit its use. Casein plastics cannot compete against moldable plastics. At present, industry is searching for a practical protein molding material free from the weaknesses of casein. Some of the more recent developments are a casein-alkylene oxide product, a casein-ethyl sulphate product, and a zein-ketene product. Many people claim we are approaching an Age of Plastics. Here, then, is a widening field of research with opportunity for the development of a product which promises to have a wide range of uses.

➤ THEORETICAL EQUATIONS *illustrated by actual samples of the products enliven John T. Hopkins' exhibit. He is exploring the diazotizing reaction for the formation of complex organic compounds.*

Complex Compounds

by JOHN TAYLOR HOPKINS, IV., 17
Roosevelt High School, Washington, D. C.

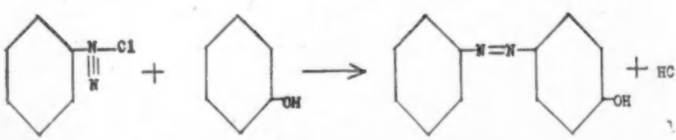
➤ BY COMPLEX compounds are understood, at least for the purposes of this paper, compounds of high molecular weight consisting of repetitions of the same units, joined together by condensation or polymerization into large molecules, like those of cellulose, bakelite, and similar substances. Industrially they are of greatest importance, for they constitute the resins, plastics, synthetic rubbers, and other valuable articles of commerce. Their uses must run into at least the hundreds of thousands, and they are increasing continually. Nearly every large chemical concern employs a large research staff to investigate possibilities of new sources, new uses, and new manufacturing processes for them. Indeed, popular literature on the subject informs us that the newest plastic is not more than an hour old, and will probably be supplanted before another hour rolls around.

The idea of my project, then, is an investigation of the diazo reaction to learn whether any useful complex compounds can be prepared from it or by its aid. It was first conceived over a year ago; I had become interested in the diazo reaction and had already performed several experiments in that field, when the possibility of obtaining complexes from it suggested itself by the following considerations as I was studying the mechanisms of diazotation and coupling:

1. Primary aromatic amines, with few exceptions, when treated at 0 —5 c. with sodium nitrite and an excess of mineral acid, undergo the so-called diazo reaction, first discovered by Peter Griess in 1858, to form the unstable benzenediazonium salt as follows:

$$C_6H_5NH_3Cl + HNO_2 \rightarrow \underset{\underset{N}{|||}}{C_6H_5NCl} + 2H_2O$$

2. If the solution is then made slightly alkaline, the diazonium salt is capable of "coupling" with phenols or aromatic amines, thus:



3. When a solution of a diazonium salt is made alkaline, there is formed reversibly the unstable benzenediazo hydroxide (see diagram, p. 16), presumably the substance responsible for coupling, which, though its parent substance was an amine, does not show any tendency to couple with itself. Of course, the obvious reason for the absence of coupling is that the diazotization has destroyed the identity of the amine, and hence made it incapable of coupling.

This, however, immediately suggests the next point, which is:

4. If another amino or phenolic group were present in the molecule, would the diazotate (diazo hydroxide) couple with itself if made alkaline; i.e., would the presence of such a group cause coupling to occur on the diazotized ring, thus producing theoretically a complex condensation polymer?

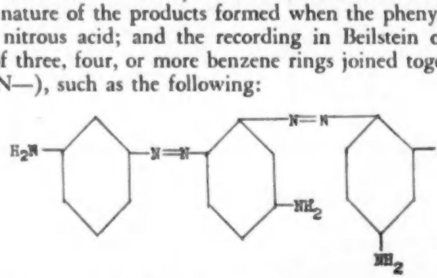
A little research unearthed a slight confirmation in Conant's "Chemistry of Organic Compounds" (Macmillan, 1939), to wit: "They (phenylene diamines) react with nitrous acid to form diazonium compounds, which then undergo condensation to form complex compounds." The important questions were, could any other substances be made to do likewise; could the formation of complexes be controlled; and could anything useful be done with them, if they were really obtainable. Since the problem interested me greatly, I decided to investigate it further.

The very first thing to be done, of course, was the development of a suitable plan of procedure. Since the project was evidently going to take the form of a trial and error investigation of all the possible means of obtaining complex compounds from this reaction, the classification and evaluation of all these possibilities would first have to be considered. This, in turn, would require a good working knowledge of the diazo reaction from the experimental standpoint as well as the theoretical. Thus the first real step devolved of necessity as the further study of that reaction.

This study was undertaken last spring and the first part of last summer, both by experiment and by library research. The experiments performed were essentially repetitions of such representative diazotations and couplings as it seemed most profitable to perform. Unfortunately, my experimenting was limited here, as elsewhere, by difficult circumstances, among which were paramount the shortages of apparatus and reagents due to the war, and the limitations of an apartment bedroom laboratory, although this last was later overcome in part by the use of the kitchen whenever possible. For, although the diazo reaction itself does not require a great abundance of equipment, the preparation of many of the raw materials used in it demands facilities that were quite unavailable.

Nevertheless, a wide range of experiments was performed, including the diazotization of several amines and the coupling with a wide variety of both phenols and amines. In general, the accepted accounts of the diazo reaction in numerous texts were corroborated, and much was learned that was of use in examining the possibilities for securing complexes. Of greatest importance was the observed fact that it was much easier to secure good coupling of diazotates with phenols than with amines, for amine coupling was almost invariably accompanied by undesirable side reactions, especially if the amine used was not of impeccable purity. The successful controlling of amine coupling was usually a delicate procedure, and the isolation of the desired product was often difficult. A variety of miscellaneous information not pertinent to the topic, but of an otherwise interesting and noteworthy nature, was also obtained.

Much was also learned from a variety of chemical literature, which included Beilstein's "Handbuch der Organischen Chemie," Thorpe's "Dictionary of Applied Chemistry," and texts by several outstanding figures in organic work. The chief facts gleaned from them were: the existence of several methods of preparing diazonium compounds besides the treatment of amines with nitrous acid, e.g., by the action of nitrosyl sulfuric acid on an amine in sulfuric acid solution; the nature of the products formed when the phenylene diamines are treated with nitrous acid; and the recording in Beilstein of several definite compounds of three, four, or more benzene rings joined together by azo linkages (—N=N—), such as the following:



2.

With these facts in mind, the enumeration of possibilities was begun in late spring and early summer. Of course, nothing was assumed to be final, as the list in time would probably undergo several alterations, but the list as it stood seemed fairly complete. At the head stood the three isomeric phenylene diamines, for which perhaps the indications were most promising, in spite of the above-mentioned difficulties that might be encountered with amines. The ortho isomer was immediately eliminated from consideration, for the time being, at least, since as soon as one of its amino groups is diazotized, it condenses immediately with the adjacent group on the same ring to form aziminobenzene, which is no longer subject to the diazo reaction. When metaphenylene diamine, however, is subjected to diazotation by ordinary methods, both the diazo and tetrazo (di-diazotized) derivatives are formed, which couple with unchanged and partially diazotized diamine to produce the dye Bismarck Brown, a mixture of compounds of two to four or five rings linked together by the azo group, such as were mentioned above. Meta-phenylene diamine can also be completely tetrazotized by a slight change in the laboratory technique. Similarly, the para isomer under ordinary conditions forms di- and tetrazo derivatives, which couple with unchanged and partly changed diamine to form various complex residues. Thus, since the diamines showed some promise already, since they were probably most adapted for experimenting under restricted conditions and since they apparently would be easily accessible (this was mistaken), it was decided to use them as a starting-point for the actual work, and to try some of the other possibilities later, when conditions might be better.

It had been my plan to spend the early part of the summer gathering and preparing the necessary reagents, and the latter part performing the experiments on the diamines, but because of several unfortunate occurrences, notably

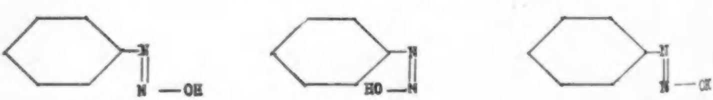
the delay of shipment of several vital reagents and pieces of equipment, it was not until the very end of summer that I was able to begin in earnest. It was necessary, too, to start with the commercially available para-phenylene diamine instead of the unavailable meta compound, whose preparation, only recently made possible by the arrival of certain materials, would have taken up much valuable time. Indeed the first experiment with para-phenylene diamine was barely completed by school time, with several tests remaining to be made whenever possible. It involved the addition of sufficient sodium nitrite to the diamine in cold hydrochloric acid solution to diazotize theoretically one amino group on each ring. The acidity of the solution was then reduced with sodium acetate, with the resultant formation of a suspension of a dirty red-brown substance. A few trials showed that the separation of a dark brown precipitate was caused by the addition of sodium hydroxide, with the evolution of some nitrogen, and the whole was thus treated to obtain the first real product. When

▶ BIOLOGICAL SUBJECTS *interest Josephine Raskind and Richard Lewontin, schoolmates from Forest Hills, N. Y., High School. Richard's project was on respiration and conjugation in Rhizopus Nigricans, Josephine's on embryology of the Physa.*

heated slowly, a part of the precipitate sublimed, beginning at a high temperature and extending over a considerable range; the rest began to decompose at a point just a little short of luminescence. Solubility tests showed that the residue consisted of several substances of different solubilities, but of probably similar chemical properties, because all were dissolved by, or insoluble in, the same solvents. A test for nitrogen is still awaiting the procurement of some sodium. The general indication, then, is that the residue consists of some kind of complex substances of different sized molecules, perhaps like the two to five ring complexes mentioned above. This is small compared to the size of a commercial resin, but it may well be a step in the right direction. At any rate, I intend to continue the investigation whenever the time can be spared.

After the possibilities of the diamines are exhausted, there are still extant several others, of which let us mention the two most important. First, as might be expected, there is the possibility of the occurrence of a type of reaction in aminophenols similar to that in diamines. The analogy with diamines is evident if the ability of both amines and phenols to couple with diazotates is recalled, although there is nothing in the literature to stimulate the aminophenol attempts as there was for the diamines. The simple aminophenols, then, together with more complicated compounds containing several amino and phenolic groups, form probably the next best field after the diamines.

The second remaining possibility of importance, which is as yet only quite theoretical, is based on the idea of coupling outside of a dissolving medium. As coupling is presumably brought about by a 1,4 addition of synbenzenediazo hydroxide to the amine or phenol undergoing coupling, with subsequent loss of a molecule of water, it might conceivably be secured in a dry state by fusion, catalytic dehydration, or other means. This obviously depends on the ability to isolate diazonium or diazo compounds in a solid state. Although most of the diazonium salts are quite explosive, it is feasible to prepare certain diazotates, notably anti-benzenediazo hydroxide and potassium isodiazotate, by several means. Anti-benzenediazo hydroxide, the geometric isomer of synbenzenediazo hydroxide, as is here shown, is not prone to coupling in solution, but there is no evidence in the literature to indicate that it definitely would not undergo such dry coupling. (Syn-benzenediazo hydroxide itself is out of the question, as it is too unstable to be isolated in the dry state.)



Anti-benzenediazo hydroxide | Syn-benzenediazo hydroxide | Potassium isodiazotate 3.

Probably if such a mode of coupling could be perfected and used, either as a single development or in conjunction with the diamine or aminophenol fields, it would be of considerable industrial importance, for not only can anti-

benzenediazo hydroxide and related compounds be prepared by several methods other than diazotization and alkalization which might be more convenient from a commercial standpoint, but the problems connected with the aqueous solution are also obviated.

So far, then, the project takes the form of a search for the needle of experimental certainty in the haystack of theoretical possibility. It is difficult to say definitely whether anything of importance may be found, but the possibility is certainly not so poor as to be discouraging. Probably whatever product might be obtained would be limited to uses of service rather than appearance, for the highly chromophoric nature of the azo linkage would color it a mottled brown or black. This, of course, would be merely one of the many technical problems that would present themselves.

In any eventuality, the subject is to me an appealing one, worth working on, that will be as interesting in the pursuit as in the outcome.

Sulfuric Acid

by Donald James Shombert, 17
Taylor Alderdice High School, Pittsburgh, Pa.

▸ When I first became interested in chemistry, three years ago, I was impressed with the variety of uses, and the great importance of sulphuric acid. It is called "The King of Chemicals," and it has been said that a nation's economic progress can be followed by its production of sulphuric acid. Inspired with ideas like these, and a very small knowledge of chemistry, I set out to make it for myself. I reasoned that from it I should be able to make many other chemicals, and equip a laboratory. The only chemicals I possessed at the time were sulphur and some common household articles, such as baking soda, chlorox (sodium hypochlorite), etc.

My first attempt to prepare sulphuric acid was a modified chamber process. Some potassium nitrate was purchased from the drugstore, and heated in a test tube to produce potassium nitrite. This, when heated with vinegar, gave oxides of nitrogen. The apparatus consisted of a bottle, with a cork in it containing four holes. Three tubes led into the bottle, one admitting nitrogen oxides, the second admitting steam, and the third sulphur dioxide, formed by burning sulphur. The sulphur furnace was a tin can, with holes around the bottom to admit air, and an exit tube at the top. The apparatus was very crude, and the sulphur dioxide almost refused to go through the pipe, but I did obtain about a teaspoonful of liquid which turned litmus faintly red. The science teacher at school, Mr. Hoopes, tested it for me with barium chloride, and found that it gave a very faint sulphate reaction. This was not too discouraging, and several weeks later I was ready to try again.

The second idea I had was to oxidise sulphurous acid by means of heated oxygen. The first step was to burn sulphur and dissolve the sulphur dioxide in ice water. This proved to be difficult, for the sulphur dioxide would not go

where I wanted it to. I tried to surmount the difficulty by burning sulphur in a bottle fitted with two tubes. Blowing into one was to supply oxygen for combustion, and the sulphur dioxide was to escape through the other, and dissolve in the water into which the exit tube dipped. Unfortunately, all I accomplished was blowing out the flame. After trying for some time, I devised an ingenious solution. The bag of our vacuum cleaner was removed, and a funnel placed over the mouth of the exhaust. The blast of air from the funnel tube was led by a rubber hose to a bottle, fitted with a two-hole stopper, in which sulphur was ignited. The exit tube from the bottle dipped under water, in which the sulphur dioxide, formed by the combustion of sulphur, dissolved. To oxidise the solution of sulphurous acid thus obtained, I planned to use oxygen, obtained from the electrolysis of water. It took some time to find a battery charger which had been lent to a relative. Armed with two amperes D.C. from the battery charger, I tried to electrolyse water. Not having sulphuric acid as an electrolyte, I experimented with other substances, trying to find something which would not be itself permanently decomposed by the current. Best results were obtained with lye (sodium hydroxide). The difficulty here was that the electrodes wore away too rapidly. Carbon, obtained from flashlight batteries, proved worthless, as it disintegrated (apparently it was composed of graphite, held together with a binder, which was attacked by the solution); metal electrodes corroded rapidly.

During our Christmas school vacation, I had taken over a corner of the cellar, as a laboratory, and had built a table and shelves. My brother had given me the chemistry equipment which he had owned as a boy, and now I could experiment with better success. For the next half year or so, I had no ideas which were of much account, and had to be content with reading about the subject and trying a few impractical experiments, which were, briefly:

1. The reaction between potassium permanganate, manganous sulphate, and water:

   $$2KMnO_4 + 3MnSO_4 + 2H_2O = K_2SO_4 + 5MnO_2 + 2H_2SO_4$$

   As a method of making sulphuric acid, this would be ridiculously expensive, but I tried it to see if it would work. An interesting fact which I noticed about this reaction is that, instead of black MnO_2, brown $MnO(OH)_2$ was obtained.

2. The decomposition of Ferric sulphate to form sulphur trioxide, and the reaction between this and water to form sulphuric acid (of which it is the anhydride):

   $$Fe\,(SO_4)_3 = Fe_2O_3 + 3SO_3, \qquad SO_3 + H_2O = H_2SO_4.$$

   This experiment was not successful because of the high temperature necessary to decompose the ferric sulphate, and, once decomposed, the difficulty of dissolving gaseous sulphur trioxide in water. To do this, I made a dissolving tower. The tower did not work with sulphur trioxide, but was very efficient in dissolving ammonia to form ammonium hydroxide, which I used in other experiments.

3. Attempting to produce sulphur trioxide by heating sulphur with potas-

sium nitrate or permanganate. This proved to be too dangerous, when a test tube exploded.

Not until almost a year after I began working on the problem did I succeed in making the "King of Chemicals" by a simple, more or less inexpensive method. The idea occurred to me as I was reading about the lead-acid storage battery. When a battery is charged, the acid content is increased from very low to about 30%. This means that sulphuric acid is made within the cell. Now, if sulphuric acid can be made from lead sulphate, with an electric current, it should be possible to make it from copper sulphate. I chose copper sulphate because the copper formed during electrolysis is not attacked by sulphuric acid, and because it is cheap. As it was finally worked out, the method consisted of electrolysis of a strong solution of copper sulphate, using a copper cathode, and a lead anode. At the cathode, copper is deposited in glittering crystals, which may be removed from time to time; at the anode, sulphate radicals (SO_4) are set free, which, of course, are unstable, and break up into sulphur trioxide and atomic oxygen. Atomic oxygen is very active, and attacks the lead, forming a thin coating of lead dioxide (PbO_2), which then resists further action; the sulphur trioxide combines with water to form sulphuric acid. When the current has passed for some time, the solution becomes colorless (due to the substitution of colorless hydrogen ions of the acid for the blue copper ions of the copper sulphate), and more copper sulphate is then added. The electrolysis is continued until the concentration of the acid (which I tested with a hydrometer made from a test tube and some shot for weights) reaches about 15%. It may then be evaporated to any desired strength. Of course this method is useless commercially, since sulphuric acid must be used to make copper sulphate, but I could make the acid slightly cheaper than commercial acid (Fisher's Scientific Company, the chemical supply company in Pittsburgh, sells sulphuric acid for 50c per pound: I made it for 45c per pound). I continued making sulphuric acid, in a sufficient amount to supply my needs, for about a year, when the battery charger was borrowed again, and broke.

At present I am working on a model of a lead chamber plant, which will follow, as nearly as possible, the details of a real plant. I expect to be able to produce sulphuric acid in almost the same way as it is done commercially, with the exception of a few improvements on the process, which I will try on the model. A centrifugal fan for supplying air has been built, and a sulphur burner is under construction. One of my ideas is to make the chambers of aluminum instead of lead. Aluminum is lighter, stronger, and more easily worked than lead (which is difficult to weld); also, with the enormously increased production of aluminum during the war, it will be very plentiful, and the price will probably be less than that of lead. Aluminum itself is not attacked by dilute or concentrated sulphuric acid in the cold, but when the acid is hot, as it is in the chambers, the metal is attacked. However, I believe it should be easy to find an alloy of aluminum which would be resistant.

In between working on this model, I am investigating silicon compounds, especially silicones, which is an up-and-coming field. I have already started this by preparing silicon, which is, naturally, the starting point.

Ice Cream, Grapefruit, Lemons, Tangerines, Paprika, Chile—

Vitamins In Daily Diet

By Jane Stafford

➤ Ice cream, it may surprise you to learn, can be an "excellent" source of at least two vitamins. Studies showing this have recently been reported by Dr. Arthur D. Holmes, John W. Kuzmeski, Carleton P. Jones and Frank T. Kanavan, of Massachusetts State College, in the New England Medical Journal.

"Many people," they point out, "consider ice cream as a luxury food, a dessert or an attractive adjunct to teas and other social occasions where light refreshments are served. Consequently, this food does not ordinarily receive proper recognition as a valuable source of protein, fat, carbohydrate, minerals and vitamins, all of which are essential dietary constituents."

Whether or not we recognize its nourishing value, we consume a large amount of it, the researchers observe. During 1943, ice cream was consumed at the rate of over three gallons for every man, woman and child. The retail value of the total ice cream consumed in 1943 has been estimated as amounting to at least $1,236,432,000. This is about one fourth the retail value of the whole milk and over twice the retail market value of the eggs, apples or potatoes consumed annually.

The researchers could not, however, find much information in the literature on the vitamin content of this food. So they proceeded to examine samples of coffee, maple and vanilla ice creams made at the Dairy Manufactures Laboratory of Massachusetts State College. Tests were made for three vitamins, scurvy-preventing vitamin C, carotene, the chemical which the body converts into vitamin A; and one of the B vitamins, riboflavin.

Comparison of these ice creams with numerous widely used foods showed them to be excellent sources of carotene and riboflavin for the human dietary, the researchers report. They did not, however, find any vitamin C, probably because of the large amount of air incorporated into commercial ice cream to increase its bulk. This would make the ice cream lose its vitamin C just as orange juice loses its vitamin on prolonged exposure to air. Whether the ice cream you make or purchase has the same high values for carotene and riboflavin depends somewhat, however, on whether the nature and amounts of ingredients and process of making it are the same as those for the ice creams studied.

For Vitamin C

➤ Homemakers should remember that heat and air are great enemies of vitamin C. Foods counted on to supply the family with this vitamin should consequently be protected as much as possible from these destructive agents. Oranges, tangerines or grapefruit, for example, should be cut or sliced as near to serving time as possible

If you squeeze oranges the night

before to save time in breakfast preparations, keep the juice cold and covered. The less air space between the juice and the container top the better for saving vitamin C. With these precautions, citrus juice can be stored as long as 24 hours with little loss of its most valuable vitamin, nutritionists of the U. S. Department of Agriculture state.

Don't forget that grapefruit, lemons and tangerines supply vitamin C as well as oranges. You get about the same amount of the vitamin from each of the following: half a glass, or four ounces, of either orange or grapefruit juice; a whole orange; half a grapefruit; two tangerines; two lemons. Each of these will go far toward supplying the day's needs for the anti-scurvy vitamin, C.

Since the pulp as well as the juice of these fruits contains the vitamin, it is thrifty to serve the juice unstrained and even higher economy, the government nutritionists point out, to eat citrus fruit simply halved, sectioned or sliced.

In these days of continued sugar rationing, two members of the citrus family, oranges and tangerines, can make a double contribution to the family's meals. Besides supplying vitamin C, they are sweet enough to serve as dessert, or in a salad for those who like a sweet one. They also have possibilities as sweeteners. Home economists of the Department suggest, for example: In orange gelatin dessert, if orange sections are used in addition to orange juice, sugar called for may be reduced a third or even a half.

Housewives and cooks need to guard against monotony in meals. Planning the day's meals carefully so that they furnish vitamins and all the other essentials of nourishment does little or no good if the food lacks flavor and other attributes of appetite appeal. Without these the foods will be picked at but not completely eaten. Food will be wasted and the family will not get all the needed nourishment.

Peppers for A Vitamin

Skilfully used, spices and condiments add flavor and variety to meals. Most of them rate low in nourishing substances and they are used in such small quantities that they could not contribute much food value even if they had it. Exceptions to this are paprika and chile, home economists of the U. S. Department of Agriculture remind us.

Paprika is the red spice from a mild-flavored pod pepper. It has long been known to contribute important amounts of vitamin A as well as flavor to Hungarian diets in which it was used lavishly. Even after drying and powdering, paprika rates high in vitamin A.

The hot chile, also a pod pepper, may contribute both vitamin A and vitamin C to diets in which it is used generously, tests at the New Mexico Experiment Station show.

Chile peppers are made into various products: canned green chile, green chili sauce, pickled green peppers, red chile sauce and canned mixtures of chile and meat or beans, known as chili con carne and chile con frijoles.

The New Mexico tests showed that these products differ widely in vitamin content. Fresh and canned chile peppers offer the most in both vitamins. Dried red chile is rich in vitamin A

but lacking in vitamin C. Sauces from dried red pepper likewise furnish A but not C. Sauces made from the pure pulp of the pepper are richer in vitamins than those that are diluted with water.

The New Mexico Station reports that on the labels of these products, the spelling c-h-i-l-e is used generally for the canned green peppers and sometimes for the sauce from fresh red peppers, but that the trade term c-h-i-l-i is used when the product contains dried peppers.

Plants Feed on Glass Flower Pots

➤ GROWING plants in glass flower pots will feed on the walls of the pots themselves if they are made of a new nutrient glass fertilizer. The glass will supply all the necessary food elements except nitrogen, organic matter and water.

This use is suggested by A. E. Badger and R. H. Bray of the department of ceramics engineering of the University of Illinois as one of the results of work carried out on the solubility of fused mixtures of rock phosphate, potassium carbonate, and silica.

Should proper solubilities be obtainable with the more complex mixtures, these scientists state, and costs be competitive with present fertilizers, glass fertilizers may offer interesting advantages. The ease with which glass can be manipulated, the scientists say, suggests many commercial adaptations for soilless growth experiments as well as ordinary applications for soil enrichment.

Sniffer Nose for Hydrogen

➤ THE HYDROGEN CONTENT in copper wire annealing furnaces, an element whose presence is detrimental to the process, is now continuously indicated by a new sensitive apparatus called a sniffer nose. It also detects the presence of other detrimental gases, such as oxygen and carbon monoxide, because they are usually present in quantities proportionate to the hydrogen content.

The new apparatus is a development of General Electric laboratories. It is extremely simple in design and operation, and can be used with any of the ordinary annealing furnaces now in use in wire manufacturing plants. By means of it an accurate and precise indication of annealing furnace conditions can be maintained, it is claimed, and information is provided which formerly could be obtained only by lengthy chemical analysis.

Bright annealing of copper for wire applications must take place under extremely well-regulated furnace conditions, in what engineers called a neutral or reducing atmosphere. It must contain very little hydrogen, since this gas tends to make the wire brittle. The presence of oxygen causes oxidation and the formation of the green material that can often be seen on copper roofs. The presence of carbon monoxide causes the loss of certain valuable properties of the wire.

Better Understanding of Science Sought for Liberal Arts Students

Cultural Chemistry

A NEW TYPE of college chemistry course, designed to give liberal arts students a general, non-technical picture of the science's role in the progress of civilization, is proposed by Dr. John A. Timm, director of the School of Science at Simmons College, Boston, in a report to the American Chemical Society.

Such a course would go a long way toward solving what Dr. Timm describes as one of the major problems confronting college chemistry departments—that of extending the influence of science among the citizens in general.

"They must be taught," he declares, "to understand the way in which science operates, to know not only where its authority is unquestioned but also its limitations. They must not be so dazzled by its wonders that they place their salvation in its hands."

In the kind of chemistry course advocated in Dr. Timm's report on "Problems in Chemistry Instruction," a single topic such as the nature of matter and energy, might be selected and detailed consideration might be given to the way in which man's concepts of these two fundamental entities have developed historically—"a sort of from-Aristotle-to-wave-mechanics treatment."

Along the way such concepts as atom, molecule, ion, force, heat, temperature, entropy, frequency, photon, electron, proton, neutron and so forth would be discussed. The meaning of these words alone suggests the possibilities of such a course.

Collateral reading and reports on industrial applications or on important figures in the history of science would be required. Such a course would take time to prepare. It would not be an easy one for its students. It would require a good teacher.

One of the chief obstacles to the development of such a course is the reluctance of scientists as a group to undertake it. Dr. Timm observes:

"They are willing to train their successors but in general they do not want to be bothered by liberal arts students in their classes. Least of all do they want to take the time from their research to design special courses for these—in their opinion—indifferent students."

There are, however, some chemistry teachers whose real interests lie in teaching rather than in laboratory research, but who are virtually compelled to do research to win recognition and promotion, Dr. Timm points out. If such teachers were charged with devising and conducting new courses for liberal arts students, they could perform a valuable service which they would enjoy, and thus avoid becoming "dead wood" as they now tend to do, he says.

"A good teacher must above all be well informed and he must decidedly not be lazy," Dr. Timm continues. "The time which his colleagues spend

in the laboratory he must use to keep up to date in a broader field than is possible for them. He must publish so that through his publications his influence may extend beyond the borders of his own institution. Also, through his published work his scholarship and originality may be judged as a basis for promotion."

For example, such a teacher might survey recent research in a given field and write a critical review, thus saving time for research specialists in the field and also keeping those in allied fields informed of progress which might not otherwise have come to their attention.

"This knowledge may be used to keep undergraduate courses and textbooks up to date," he notes. "The value of new information may be assessed and, if of sufficient importance, it may be introduced at the proper level of instruction. Outmoded and less important material may be eliminated to make room for it.

"The problem of devising and teaching the new courses in science for liberal arts students can be safely entrusted to such teachers. They could be of great value not only to their students but to their colleagues."

Besides trying to give liberal arts students the kind of chemical background they really need, Dr. Timm contends, colleges must endeavor to provide suitable courses in the humanities for their chemistry students, so that the latter will not have too limited a view of their social responsibilities. A more rapid advance of chemistry through research is of doubtful value "if it has to be gained at the cost of too narrow a specialization by chemists and a subsequent lessening of their influence on civilization except in material things."

At present the scope of science is growing so rapidly that the tendency to add technical courses and crowd out the humanities is bound to increase unless educators make a determined effort to develop a better balanced curriculum.

This is a good time to make such changes as he proposes, Dr. Timm asserts, since many scientists who were engaged in war work "have suddenly discovered the social implications of science research," while their colleagues in the humanities have been re-examining the liberal arts curriculum and as a result "have rediscovered the cultural value of science and are requiring more of their students."

"However," he says, "they are insisting that the traditional first courses in science will not meet their requirements. They hope and deserve to get cooperation from their science colleagues in planning and giving these courses."

On the Back Cover

➤AMBERLITE *ion exchange resins in this simplified column can be used for complete de-ionization, using two resins, as well as for such special applications as the removal of fluorine from drinking water, which requires only one.*

Fluorine Content of Drinking Water Regulated by Resin Adsorption

Water Treatment Protects Teeth

➤EXCESS FLUORINE in drinking water, now recognized as the cause of "mottled teeth" (chalky white, brown-spotted enamel) can be effectively removed by the use of Amberlite ion exchange resins, it has been announced by the Resinous Products and Chemical Company, of Philadelphia, Pa. Experimental work carried on in their laboratory and subsequently confirmed by independent organizations has shown that fluorine can be rapidly and efficiently extracted by passing the water over a bed of Amberlite IR-4-B which has been specially treated with a solution of an aluminum salt—generally aluminum sulphate. The method is ideally suited to water supplies and has proved superior to any others employed. The exchanger is not depleted in the process and can be used repeatedly by a simple regeneration process employing an alkaline solution which removes the accumulated fluorine ions.

Water containing the fluorine or fluoride salts is passed through a column containing the resin. The fluorine ion is retained and the "conditioned" water passes on through the column. When the exchanger bed is saturated with the fluorine ions, regeneration becomes necessary—a reverse chemical reaction which removes the fluorine ion from the resin and prepares the resin column for repeated use.

In the proper concentration, fluorine is responsible for the excellent condition of the teeth of inhabitants in certain localities in our country. On the other hand fluorine concentrations outside of narrow limits determined by National Health Associations are definitely deleterious to health and result in mottled teeth.

Although it has been known for some time that fluorine is removed by bone, chemical methods are relatively recent developments. The problem posed involved finding a substance which would not leave in the water any element not already present; and which would not impair the potability of the water by increasing any ordinary constituent to an undesirable concentration.

There were three possible approaches: precipitation of fluorides—unsatisfactory because of the high solubility of the fluorides; desalting, which has proved uneconomical so far; and the selective adsorption on the surface of a solid. The latter proved most promising.

Although a number of materials—titanium oxide, zinc oxide, copper hydroxide, copper sulfide, etc.—answered most of the necessary qualifications, their principal disadvantages proved to be ready disintegration, inability to be regenerated and low capacity. The use of resinous ion exchangers and their selective removal of the fluorides became the logical answer for commercial purposes.

Ancient Adhesive Still Standard For Stickiness and Sizing

History and Romance of Animal Glue

➤IN THE FIRST glimmerings of civilization, primitive man found that there were other uses to animals he killed than just food. Skins were used for protection against the cold and they could also serve in the building of rough shelters. Plaques 4,000 years old show the tanning of tiger skins. That was the beginning of man's know-how with leather. The experiences he secured in the tanning and preserving of hides and pelts led to other experiments. The result was animal glue, a powerful adhesive cooked from hide pieces soaked in water.

Among the stone carvings of ancient Thebes, and at least 3,300 years old, is one depicting the gluing of a thin piece of rare wood of red color to a yellow plank of sycamore. A pot of adhesive is being heated over a fire and several samples of veneered and inlaid woods are pictured. One figure is shown spreading glue with a brush, and a piece of dry glue with its characteristic concave fracture is also depicted. That glues were early used for other purposes is demonstrated in writings of Pliny, the Roman, who referred to their use in paints by the Egyptians. King Tut, restorer of Thebes, was buried with all of his imperial furniture. Many of the individual pieces were made of wood joined with glue. When the tomb was opened recently, the glued joints were found to be as firm as when they were first set thirty centuries ago. Children's playthings have been held together with glue for thousands of years. In the stone foundations of ancient Persian Temples can be found all types of glued toys and dolls.

Beginning with 200 B.C. occasional reference is made in literature either to glue or to the act of gluing. However, it was not until 1690 that the first commercial glue plant was founded in Holland.

First reference to glue in patent literature was in 1754. Early glue was made of hides soaked in water. First reference to bone glue occurred in patent literature in 1814. Glue making was established in America in 1808. An early compendium of 1810 listed six establishments in Pennsylvania with a total product value for the year of $53,206 and one in Maryland with a product value of $500. In 1944, total production of animal glue in America approximated 150,000,000 pounds with a sales value of thirty million dollars.

Up until the latter part of the nineteenth century, animal glue had been the only major adhesive available in commercial quantities. In the more than 3000 years that it answered almost all of civilization's need for adhesives, animal glue played a dramatic role in the perfection of many inventions. The Chinese craftsman Tsai Lun found animal glue the perfect sizing material when he invented writing paper in 105 A.D. The first cylinder printing press, forerunner of modern day printing equip-

ment, was judged a failure because a satisfactory inking device couldn't be found. The glue glycerine printing roller was the answer. The growth of the rayon industry has been marked by a proportionate growth in the consumption of animal glue by textile mills. Rayon yarn, unequipped with natural oils, needs to be sized with animal glue to prevent chafing or abrasion at the looms. Today, more than 10,000,000 pounds of animal glue are used annually by rayon mills.

Animal glue has played a vital role in both World Wars. The first World War saw the emergence of the United States as foremost producer of glue in the world. In this war, the use of adhesives in the manufacture of airplanes, cargo ships, torpedo boats, battleships, rifles, ammunition containers, engine parts for plane, auto, and tank, radio equipment and many other military items has created new interest in this age old product for peacetime use.

$C_{102}H_{151}O_{39}N_{31}$

Chemically speaking, animal glue is an organic nitrogenous colliodal substance of the protein class. The development of protein and colloid chemistry has resulted in new techniques of production and application of animal glue. Possibly no other material has been used so extensively in the laboratory in demonstrating the colloidal phenomenon.

Commercial applications of the colloidal properties of animal glue can be found in the electro-metallurgic processes and dye baths. Glues have a pronounced stabilizing effect on most kinds of water oil emulsion. Hence, their use in oil type insecticides. Another common use occurs in the clarification of solutions. Through the principal of mutual precipitation, glue and the impurity combine and drop through the liquid, sweeping it clean. In a few processes, the suspended material is what is wanted. In such cases, the glue aids in concentrating it in the precipitate. The protective action of animal glue is used in electrolytic baths to prevent crystallization and thus aid in the formation of smooth hard deposits of metal.

Animal glues are highly reactive to almost all bases, salts, and acids. Undoubtedly, many of these reactions are due primarily to the dispersed state in which glue occurs in solution. Glue is a colloid and its colloidal nature governs its behavior under many circumstances.

The chemical nature of animal glue plays a role of ever increasing importance from the time raw materials are received in the glue plant until the glue becomes part of the finished product. A basic industry, linking farm and factory, glue manufacture provides a natural outlet for enormous quantities of by-products that come in large part from meat packers and tanners. This by-product production of animal glue provides tanners and meat packers with an important source of revenue.

Trained chemists and engineers oversee the man-sized job of converting one and one-half billion pounds of raw stock each year into well over 150,000,000 pounds of finished glue of various grades to meet the needs of industrial users. In similar fashion, technicians working in the plants of the users have developed controlled methods of application.

With a long life behind it, which began over 3,000 years ago in Egypt, animal glue today is still the standard of all adhesives, versatile, simple to use, and dependable. The animal glue industry, like other progressive American industries, in its postwar plans is applying the soundest modern techniques to fit its own business into the pattern of a stable and prosperous America.

The glue manufacturer has taken advantage of practical revelations of research so far, by introducing them into the product or incorporating them into his production process. Experienced technicians with complete laboratory facilities at their disposal stand ready to assist the industrial user of animal glue on his specific and individual problem.

Chemical Things to Do:

Blueprint Paper for Photography

by Joseph H. Kraus

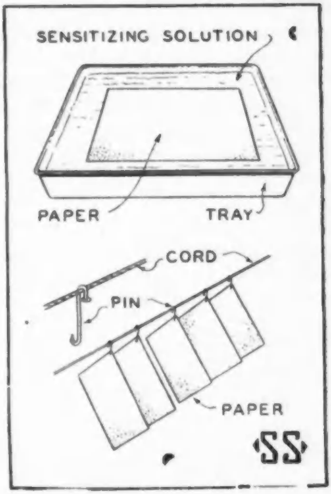
➤ Experimental test proofs of photographs can be made on blueprint paper prepared by any junior scientist. Learning the technique of making this paper will aid you in producing other kinds of photo-printing paper which can be used while paper is scarce.

There are many ways of producing one's own printing paper. Some are intricate or demand chemicals which may be obtained only with difficulty. The highly specialized papers which you can produce yourself, on the other hand, are not available from any dealer because they do not keep well, consequently must be prepared and used immediately.

One of the more simple methods of making photo-sensitive paper is by what might be called the floatation method. Perhaps the easiest of all to prepare is blueprint paper.

Make the following two solutions: Solution A—10 drams of potassium ferricyanide dissolved in four ounces of water. Solution B—15 drams of iron ammonium citrate dissolved in four ounces of water. The solutions should be kept in dark, well-stoppered bottles and may be prepared beforehand.

When ready to make your blueprint paper, select a paper stock which will not soak up too much water. A good grade of writing paper will be excellent. Art supply stores also can furnish you with paper used for water color painting. This, likewise, will give good results.



Perform these operations in a shaded room. Diffused daylight is not harmful. Mix equal parts of Solutions A and B in a flat dish. If you do not have a developing tray, you can use a soup plate. Stir the solutions well, then place your paper sheet on the surface of the solution so that it floats. In a moment the paper should contact its entire surface with the prepared chemical bath. Lift the paper by one corner and hang it up to dry, preferably in a dark room, but a dimly lighted room will do.

Hang by Bent Pins

Many sheets of paper can be hung from bent pins hooked to a string running across the room, as illustrated in the diagram.

The paper is ready for use when dry. Place your photographic negative under a sheet of clean glass and in contact with a piece of blueprint paper. Expose to direct sunlight. As much as four to six minutes exposure may be necessary.

By lifting the corner of the paper you can watch the progress of the printing from time to time. When satisfied with the results, remove the paper and wash by placing under running water or suspending in a pail of water. This removes the unaltered iron salts.

To Get Brown Tones

If you want to convert the blueprints into prints which have brown tones, immerse the dry print in water to which enough ammonia has been added to bleach the print almost completely within four or five minutes. Then put the print into a solution of tannic acid in water. Depending upon the concentration of the solution you can get from a light brown to almost black tones.

After you have experimented with blueprint paper you will probably want to make papers such as bromide or chlorobromide, or go in for specialties such as gum prints, carbo and the like. Formulas may be found in good photographic handbooks.

Fungus-Proof Cotton Fabric

➤ A MODIFIED COTTON cloth, that failed to rot during six months buried under soil where ordinary cotton would rot in a week, has been developed in the Southern Regional Research Laboratory of the U. S. Department of Agriculture. It is a partially acetylated cotton, which is somewhat related to rayon made by the acetate process.

The new material has the strength and appearance of ordinary cotton, but it has the ability to resist the attack of rot-producing micro-organisms and to resist mildew. In contrast with many preservative finishes on cotton, the treatment does not produce discoloration. The treated fabric is odorless and is not sticky. It can be used in food sacks because the fabric is not poisonous.

To test the rot resistance of the material some of the treated cloth and thread were buried in the ground and in especially prepared beds teeming with micro-organisms of the kind that would have rotted ordinary cotton within a week. After six months they had lost very little strength. Sandbags made of the acetylated cloth, sewed with similarly treated thread, and piled outdoors on the ground, were still intact after two years.

This modified cotton should be satisfactory for making clothing that will not mildew, tents and awnings that will not rot in damp climates, and fish nets that can be stored wet. It is also promising for use in making bags for fruits and vegetables.

New Drug Obtained from Buckwheat Makes Blood Vessels Less Fragile

Rutin Ready For Production

➤ RUTIN, a drug effective in reducing the increased fragility of small blood vessels which may lead to blinding or fatal hemorrhages in cases of high blood pressure, will go into full scale commercial production this year, the U. S. Department of Agriculture announces.

Discovery by the department's scientists that the green buckwheat plant is an economical source of the drug, following a two-year search for such a plant, makes possible the commercial manufacture of rutin which is described as a bright yellow, nontoxic powder.

The marked similarity of rutin's chemical structure to that of vitamin P, known for its effect on the fragility of small blood vessels, intrigued the interest of Dr. James F. Couch of the Department's Eastern Regional Research Laboratory. Following his suggestion, medical studies of rutin were made by Dr. J. Q. Griffith, Jr., of the University of Pennsylvania.

Results of his studies and those of about 100 other physicians gave further evidence, the department states, "of the value of rutin for reducing increased capillary fragility and showed that thiocyanates and other drugs for reducing high blood pressure can be used safely after treating with rutin."

Glasses Without Silica

➤ NEW KINDS of glass, made without the use of the ordinary glass sands employed for centuries, may become increasingly important. They will be developed particularly for service in optics, photography, enamels, glasses transparent to ultraviolet rays, and in special colored glasses.

These new glasses contain little or no silica, the substance long regarded as essential in glass-making, but are made with phosphates, borates or fluorides, according to Dr. Frank L. Jones of Bausch and Lomb Optical Company, who discussed non-silica glasses recently at a section meeting of the American Chemical Society.

Phosphate, borate and fluoride glasses, he says, resemble silicate glasses in general principles of chemical constitution, but differ from them and from one another in important chemical and physical properties. The non-silica glasses have already proven their value in the photographic field. For general use in the field of optical instruments, he states, it is likely that glasses intermediate between the older silica glasses and the new non-silica glasses will be especially valuable.

Chem Quiz

On the Scent

➤ ONE OF the interesting features of organic chemistry is the work-out your nose gets—and not always an unpleasant one, either. Here are the names of some compounds in one column and in the other, in scrambled order, the things they smell like. Can you match them? If not, they are blended harmoniously on page 51.

acetamide	hyacinths
amyl acetate	almonds
amyl valeriate	strawberries
benzaldehyde	garlic
ethyl butyrate	pineapples
ethyl formate	bananas
ethyl sulfide	wintergreen
methyl cinnamate	peach kernels
methyl salicylate	apples
phenyl acetaldehyde	mice

Bazooka Chemical Useful in Varnishes

➤ THE SAME stuff that put such a "bang" in the bazooka's tank-killing rocket projectiles, given different chemical handling, becomes an excellent material for varnishes and other coating resins, at least partially replacing tung oil.

The compound's name is pentaerythritol. Although it is a dry white powder at ordinary temperatures, it is chemically classified as an alcohol. It is made synthetically from formaldehyde and acetaldehyde, which themselves are synthetic compounds, so that its supply is not so likely to be diminished or disturbed by either war or weather as are supplies of imported natural products like tung oil.

Moreover, it is relatively low-priced. In 1940, drying oils based on pentaerythritol could be bought for 11 to 15 cents a pound, while tung oil was selling at 18 to 24 cents a pound. Since war demands brought about a great increase in pentaerythritol production, it is likely that this favorable price differential can be increased now that it is no longer needed for loading rockets, shells and mines.

As used in bazooka projectiles and other military missiles, the compound has four nitrogen-containing atomic groups attached to it. These convert it into pentaerythritol tetranitrate, referred to as PETN for convenience; this is an explosive so violent that TNT is usually added to it to slow it down a little, and make it less "touchy."

For use as a varnish, pentaerythritol is combined with rosin acids, fatty acids or other organic chemicals. Thus treated, it is said to be able to hold its own in competition with the older coatings made with tung or other **vegetable oils.**

Soapless Detergents Have Promising Future

Synthetic Soap Subs

Reprinted from the Arthur D. Little Inc. Industrial Bulletin

▶ SOAP, ONE of chemistry's earliest contributions to better living, is facing real competition. The synthetic detergents, first introduced to meet special industrial problems which could not be met by soap, have recently been produced in great volume. Their costs have been reduced by virtue both of large-volume operations and because of new production developments. As a result, the synthetic detergents are being merchandised on a large scale to the householder for cleaning jobs where soap is not at its best, especially in hard water areas.

The newer detergents include a multitude of chemical types and have been called synthetic because they were developed by modern chemical research, whereas soap making is an ancient art. Soap is itself a synthetic, however, resulting from the reaction of caustic soda and a fat. Their molecular structure enables soap and the newer detergents to creep under particles of soil, lift them from their base and suspend them in water; these cleaners can also break up grease, which would not otherwise mix with water, into small particles which can be suspended in water and carried away. But soap also has limitations; it forms insoluble curds with the calcium in hard water and is destroyed by acid solutions sometimes required in laundries and other industrial washing operations. In contrast, many synthetics are effective in hard water and can be used in neutral or acid solutions.

Interest in the newer detergents has become so widespread that some producers are planning capacity increases, and a number of other companies, including alkali producers and petroleum refiners, are understood to have detergents in the development stage ready for early commercialization. The United States production rate in late 1943 was somewhat over 90,000,000 pounds per year. Indications are that when expansions now underway or planned are completed, this country's productive capacity for synthetic organic detergents may exceed 350,000,000 pounds annually or nearly four times that estimated for 1943. Although soap production in a normal year has been of the order of 3 to 4 billion pounds, the anticipated annual volume of the new detergents is nevertheless attaining significant proportions and the peak is apparently still to be reached.

These products, like soap, can be manufactured in granule, flake, and liquid forms, and some of them are compatible with soap and can be formed into cakes for general toilet use. Synthetic detergents will wash satisfactorily in both hard and soft water, and even in cold sea water, without causing undesirable curds to deposit on garments or washing vessels. They are especially effective on woolens. Used in the household, the newer detergents eliminate "rings" in

tubs and sinks and greatly facilitate dishwashing because of their excellent grease-removing properties. In addition, the detergents find application in such varied products as liquid and paste dentifrices, and special compounds for dairy cleaning and metal degreasing.

Synthetic detergents, first developed in Germany after World War I, came into common industrial usage, especially in the textile field, in the United States in the early 1930's. A few household products were marketed before World War II, but these were largely withdrawn during the war because of the increased demand for synthetic detergents for Navy and Merchant Marine "seawater soaps," for use in Army mobile laundry units, which frequently dealt with especially hard waters and difficult soils, and for a variety of industrial uses. In addition, supplies of coconut oil, a raw material for some of the synthetic detergents, were greatly reduced, and this necessitated utilization of the oil itself and of the derived detergents where war needs dictated.

Among the more widely known synthetic detergents are the Gardinol Corporation's Gardinols and duPont's Duponols, both industrial products. Proctor and Gamble offers Orvus and also Dreft for household cleaning and Drene, a shampoo. The Nacconols, produced and sold for industrial use by National Aniline Division, Allied Chemical and Dye, are manufactured for household use as Swerl by that company's Swerl Products Division, and distributed by H. J. Heinz Company. The Colgate-Palmolive-Peet Company offers Vel for household cleaning and Halo as a shampoo. Santomerse of Monsanto Chemical Company, the Igepons and Igepals of General Aniline and Film Corporation, and Ultrawet of Atlantic Refining Company are all industrial products.

Although synthetic detergents were originally much more expensive than soap, the price of at least one leading product has now been reduced to 13c per pound in industrial quantities. Comparable soap prices are slightly lower, but for many purposes the synthetics are more efficient and hence less costly to use. Further reduction of synthetic detergent prices is anticipated.

Water For Drinking Sterilized

➤ WATER FOR drinking purposes is sterilized, to destroy microorganisms and free it of all biological contaminations, by a treatment, just patented, in which it first is subjected to positive pressure and moderate heat, and then injected in a high vacuum. The patent was granted to James A. Camelford here, who has assigned it to the Buckeye Laboratories Corp.

In the process, the contaminated water is strained or filtered to remove solid impurities, and then passed through a high-pressure pump which puts a pressure of from 1,000 to 4,000 pounds per square inch on it. It is heated to about 125 degrees Fahrenheit, then sprayed through a nozzle into a vessel maintained at as nearly a perfect vacuum as possible. The result is a palatable water relatively free of biological contaminations.

Scientists Who Developed Atomic Energy Interpret Phases of Nuclear Fission

The Meaning of Atomic Energy

The four talks on the outstanding consequences of the atomic power research program, here brought together because of their interest to chemists, were given by their authors on successive Sundays over the Columbia Broadcasting System Network as part of the Philharmonic Symphony —United States Rubber Co. program. These scientists played leading roles in the opening of the atomic age. They present here the conditions and the results of the new forces they have mastered.

Within the Atom

by HANS ALBRECHT BETHE

Dr. Bethe, in charge of the Theoretical Physics Section at Los Alamos, developed the first acceptable theory of the nuclear transformations by which the sun produces its energy. Born in Strasbourg, France, and educated in Germany, he came to America in 1933 and became a professor at Cornell University.

▶ THE ATOM is the hero of the day. It is the most democratic hero you can choose, because it is everywhere and in everything. All matter is composed of atoms. Indeed, matter consists of nothing but atoms, and there are incredible numbers of them. A spoonful of water contains a million billion billion atoms.

The classical idea of the atom pictured it as solid and indivisible. In fact, the word atom means that which cannot be divided. About the beginning of this century science discovered that the atom itself is made up of smaller parts; in other words, it has a structure. In 1910 the great English physicist Lord Rutherford stated on good evidence that every atom consists of a positively charged nucleus surrounded, like a central sun, by a negatively charged planetary system. The planets of this atomic world were named electrons, and each electron is a particle of negative electricity.

It was found that the number of electrons revolving around the nucleus depended on the number of charges of positive electricity that were carried by the nucleus. Thus, the hydrogen atom has one unit of positive charge—and it has one revolving electron. Uranium, the heaviest natural element, has 92 units of positive charge, and we find that its nucleus is surrounded by 92 revolving electrons. Between these two extremes—hydrogen the lightweight and uranium the heavyweight—are all the various combinations of positive and negative charges which exist in nature and which constitute the varieties of atoms.

The nucleus is the massive center, which contains almost all the atom's mass. The electrons are the electrically negative particles which revolve around the nucleus. It is the number

of electrons in an atom that governs the chemical properties of the atom. The electrons, for example, determine that one atom of oxygen will unite with two atoms of hydrogen to form the familiar molecular pattern, H_2O, of water.

While the modern theory of atomic chemistry was being developed, physicists went on to explore the atomic nucleus and found that it, too, had a structure. To be sure, in the one case of hydrogen, that lightest of the atoms, the nucleus was found to consist of a single particle—but in all the other ninety-one elements the nucleus was itself a combination of yet smaller particles. Experiments revealed that these particles of which the nucleus is built were of two kinds—*protons* and *neutrons*. Lord Rutherford discovered and named the proton, and some years later one of his students, Sir James Chadwick, discovered and named the neutron.

In mass or weight protons and neutrons are about equal, but in electrical properties they are quite different. The proton is positively charged, and the number of positive charges in the nucleus is equal to the number of protons contained. Thus hydrogen, with its one positive charge, has one proton. Uranium, with 92 positive charges, has 92 protons.

The neutron, on the other hand, carries no charge at all—is electrically neutral, hence its name. But it weighs approximately the same as the proton. The oxygen we breathe has a nuclear structure made up of 8 protons and usually 8 neutrons—and its weight therefore is 16. Uranium—the kind used in making the bomb—has 92 protons and 143 neutrons, giving it an atomic weight of 235. Atomic weight is the sum of the number of protons and neutrons carried in the nucleus.

The neutrons and protons within an atomic nucleus are held together by the most powerful forces known. Remarkably little is understood of these nuclear forces, even after many years of research. We do know that they are enormously strong — more than a million times stronger than the chemical forces which hold oxygen and hydrogen together in the water molecule, while these chemical forces in turn are many times stronger than the elastic forces which hold together a lump of steel.

There is a direct way of measuring the strength of nuclear forces. It depends upon the fact that the combined mass of all the neutrons and protons inside any given nucleus is about 1 per cent less than the sum of the masses of the individual neutrons and protons. This fact tells us that when the neutrons and protons are put together to form the nucleus, some of the mass of the individual particles is converted into energy in accordance with Professor Einstein's law of the equivalence of mass and energy.

And by measuring the loss in mass we are able to compute from Einstein's equation the strength of the nuclear forces. I can assure you it is enormous. For instance, one ounce of mass is equivalent to the energy output of the great power plant at Boulder Dam for a whole month. Therefore, the observed small difference in mass in the atomic nucleus indicates that the nucleus contains considerably less energy than the

separate protons and neutrons of which it is composed, and this large energy difference measures the strength of the nuclear forces. It is worth noting that energy would have to be supplied in order to tear the nucleus apart into its protons and neutrons—therefore such atom splitting would not be a source of atomic energy.

With one exception, no nucleus has been completely split into protons and neutrons. The more usual experiments consist of the transformation of one kind of nucleus into another, and this is what is popularly called "splitting the atom." These transformations can be initiated by bombarding a nucleus with some form of minute projectile. Protons have been used, but since the proton carries a positive charge, and since the nucleus of every atom is also positively charged, the nucleus tends to repel any proton moving toward it. Thus only by accelerating the protons to very high velocities can physicists score an occasional hit.

The neutron was discovered in 1932, and as soon as it was tried it proved to be an ideal projectile for this purpose. For since it carries no electrical charge, it is not subject to forces of repulsion.

Several hundred nuclear transformations were investigated in the 1930's and they had one result in common: when the bombarded nucleus broke into two fragments, one of them was always very small, while the other contained all the rest of the nucleus. This could hardly be called atom splitting.

But in 1936, for the first time, a heavy nucleus was split into almost equal parts. It was found that when a neutron hit the nucleus of Uranium-235, the nucleus separated into two fragments, one weighing about 100, the other about 135. This is ***nuclear fission*** and is the basic principle of the atomic bomb.

Immediately after the discovery of this process, physicists were able to calculate the amount of energy set free by fission, following Einstein's principle. True, the difference in mass between the uranium atom and its fragments was only one-tenth of 1 per cent. But, as we have seen, this still corresponds to enormous energy.

The most important fact about fission is that neutrons are emitted in the process. Let us suppose that in a fission two neutrons are emitted. Then, if we supply just one neutron to a large block of Uranium-235, it will cause the fission of one atom, that will lead to the emission of two neutrons, each of these will produce fission, resulting in the emission of four neutrons, and this multiplication will continue indefinitely. As the freed neutrons multiply, the energy stored in the uranium nucleus is liberated. If it is not stopped, the process will go on until all the uranium in the block is split.

If unchecked, such a nuclear chain reaction leads to the violent explosion of the atomic bomb. But the chain reaction can also be perfectly controlled and may some day be used for the production of atomic power. We see, therefore, that the release and control of atomic energy is now a reality. But the physicists have not reached their goal. They are still seeking to understand the nature of the gigantic nuclear forces.

Isotopes in Atomic Research

by Harold C. Urey

Discoverer of heavy hydrogen, Dr. Urey served as a program chief responsible for isotope separation in the Manhattan Project. American by birth, this former professor at Columbia University has joined the new Institute of Nuclear Studies at the University of Chicago.

➤ Since the atomic bomb exploded over Hiroshima and Nagasaki, it seems much easier to talk about isotopes. Everyone who reads the newspapers now knows that isotopes exist, that uranium-235 is the explosive kind and that uranium-238 is not explosive. We also know that the separation of these two isotopes was necessary before the uranium-235 bomb could be made, and that it was a difficult problem to separate even small amounts.

While frequent references to these subjects in the newspapers have made us familiar with the term, I think you may be interested in a more precise discussion of isotopes—what they are, why we wish to separate them, and the methods by which this is accomplished. In the first place, let us understand that isotopes are simply atoms of the *same element* but of *different weight.*

Those of you who listened last Sunday to Professor Bethe's address in this series, will remember his discussion of the three primary particles—protons, neutrons, and electrons. The protons are positively charged massive particles which reside inside the atomic nucleus. The electrons are the negatively charged particles which revolve around the nucleus. The third kind, the neutrons, are electrically neutral, and like the protons are found only within nuclei.

Neutrons have about the same mass as protons, and the weight of an atom is the sum of the weights of its protons and neutrons. (Electrons, I may say parenthetically, are so extremely light that their masses can be ignored in discussing the weight of the atom). The weight of an atom, therefore, is the sum of the weight of its protons plus the weight of its neutrons.

Now, the number of protons in the atoms of any one element is always the same. In the case of uranium, for example, and no matter which isotope of uranium we are talking about, each atom has exactly the same number of protons—92. There is one kind of uranium which weighs 234, another kind which weighs 235, another 238, still another weighing 239. Since each has exactly 92 protons, the weight differences can be accounted for only by differences in the number of neutrons. Therein is the explanation of isotopes. The uranium-238 has 146 neutrons in its nucleus, whereas the explosive isotope, the uranium-235, has three fewer neutrons.

As you go through the list you find that almost every chemical element has atoms of different weight—that is, has different isotopes. Most of the hydrogen in the world weighs around 1 unit, because its nucleus consists of a single particle, a proton.

But there is a small proportion of hydrogen atoms which have a double-weight nucleus, consisting of a proton and a neutron. Other elements

also consist of mixtures of isotopes. Carbon, for example, has two isotopes, nitrogen two, oxygen three, and so on.

I hope it is clear, from this rather abbreviated explanation, what isotopes are. They are atoms of the same elemental substance, which differ from one another in weight, and these differences are accounted for by the varying numbers of neutrons in their nuclei. The atoms which have few neutrons in their nuclei are called light isotopes, and those with the most neutrons, the heavy isotopes.

But why should we want to separate isotopes? The answer is easy. It is only by separating, by isolating the material he is interested in, that the research man can investigate its properties. In the case of uranium, as soon as it was found that the rare uranium-235 was the isotope subject to fission or splitting, it became a major task to separate it from the more plentiful uranium-238.

The separation problem is difficult because we are dealing with a mixture of atoms of the *same* chemical element, whose differences in physical properties are usually very slight.

Simple distillation of water is sufficient to separate the light isotopes of hydrogen and oxygen from the heavier ones—the light atoms are more readily carried over in the vapor. Similarly, the relative numbers of isotopes of carbon and oxygen in the carbon dioxide escaping from your glass of soda water differ from the relative numbers of these isotopes that remain in solution. This distillation or chemical method has been used to separate isotopes of hydrogen, carbon, nitrogen, and sulphur; and its feasibility for the separation of lithium, oxygen, and perhaps potassium, has been indicated. But unfortunately the differences in mass become relatively smaller as we take up elements of higher mass, and the method does not look promising for elements above atomic weight 40. So we try other methods.

If you have a gas or a liquid between two plates, keep one plate hot and the other cold, the lightweight isotopes will tend to move toward the hot surfaces and the heavy ones toward the cold surfaces. Considerable separation can be attained by this so-called thermal diffusion method.

Another method uses centrifugal force. In rapidly rotating centrifuges the heavy isotopes move outward to a greater extent than the light ones. This method seems feasible for quite a number of elements, though difficult.

Not one of these three methods—distillation, thermal diffusion, or centrifugation—proved practicable in the case of uranium. In some ways I was sorry about this, but in some ways quite glad. In a war problem, one wishes to get the work done as rapidly as possible and thus shorten the war. On the other hand, if the uranium isotopes could be separated by an easy method, they could be separated in almost any garret or basement laboratory. Hence atomic bombs could be made without the necessity of large industrial plants. And, of course, if they could be made in that way, it would be difficult to know whether people were making them, and the whole problem of control of the atomic bomb would be much more difficult than it is.

Since the easy methods would not work, we had to turn to more difficult ones—and first of all to separation in electromagnetic fields. In this method the uranium atoms are given an electrical charge, and a stream of these electrified atoms is shot between the poles of a powerful magnet whose effect is to cause them to pursue a circular path. But the greater inertia of the uranium-238 causes it to resist the pull of magnetism more than the lighter uranium-235; hence the two isotopes become separated.

The other method used was the diffusion method. This depends on the rate at which gaseous molecules flow through porous material. You can set up a system, for example, in which air flows through blotting paper, and because the atmospheric *nitrogen* is lighter than the *oxygen*, the nitrogen will flow through more rapidly. In the same way the lighter uranium-235 atom diffuses more rapidly than the heavier 238. The separation is very small. To change the relative abundance of the isotopes by large amounts requires that the process be done over and over again thousands of times—and this is one reason for the mammoth size of the separation plants pictured in the newspapers.

What of the future? Since uranium isotopes are the most difficult ones to separate, and since we have succeeded with them, we are confident of our ability to separate the isotopes of any element. However, it takes a very valuable isotope to justify the immense amount of work done on the atomic bomb project. Mostly, we do not wish isotopes that badly. We should note, however, that a few years ago we did not want uranium isotopes. Nitrogen isotopes are now articles of commerce. Hydrogen isotopes have been separated in large quantities. It may be that some day we shall want isotopes of lithium, boron, carbon, or sulphur—so it is well to have methods in advance.

We are at the beginning of a vast new chemistry—one concerned with changes taking place within the nuclei of atoms. Part of this work involves securing separated isotopes for these studies. To the layman, what has already been done may be the most interesting, but to those of us at work in this field it is the unknown thing ahead that has maximum interest. Particularly, young men and women should realize that science is an ever-expanding universe with always the most interesting discoveries still to be found.

The radioactive isotopes produced by methods used in producing the atomic bomb will have many uses in studying chemical and physical processes both for purely scientific and industrial work. They should have many uses in medicine. They can be made by methods which for the most part do not require the separation of isotopes by the methods that I have indicated. At the same time the separated isotopes particularly of hydrogen, carbon, nitrogen, oxygen and sulphur should also be useful for similar studies. For example, we can use both stable and radioactive isotopes to follow elements through complicated systems such as living animals. Thus nitrogen in food, if it is heavy nitrogen, can be followed through the complicated chemical processes that occur in an animal body. Or radioactive carbon or heavy carbon may be fol-

lowed in the same way. During the next 25 years we should learn a great deal about such processes.

During recent years we have heard much about the usefulness of science, that is, the justification of science on the basis of its usefulness for peaceful or military things. I believe this point of view is not as broad as it should be. Science is an end in itself, just as literature and art are. Our primary objective should be to learn fundamental things about the behavior of natural phenomena. We wish to know all about the structure and behavior of the heavy nuclei of atoms, what holds the protons and neutrons together, the details of the splitting of atoms, why they are stable or radioactive, what new fundamental particles there may be in nature beyond protons, neutrons and electrons, and many things of this sort. The separation of isotopes is only one of very many modes of attack on these fascinating problems in our study of these very small and energetic nuclei of atoms.

Medical Benefits from Atomic Energy

by JAMES FRANCK

Formerly the director of the physical laboratory at Göttingen, Dr. Franck of the University of Chicago has for many years been deeply concerned with the interaction between radiations and living organisms.

➤ SINCE THE ANNOUNCEMENT of the first atomic bomb, a great deal has been said about the *destructive* power of the new explosive. But there is also a *constructive* aspect of the atomic age. Two questions present themselves. First, will our new-found ability to tap the energy within the atom promote progress in biochemistry and medicine? Second, can important beneficial results be expected in the near future? My answer to both questions is "Yes." We may look for rapid and important benefits, provided we keep scientific progress from being stifled by considerations of military security. Let me tell you why I take this optimistic view.

The structure of the atom was explained in Professor Bethe's address in this series two Sundays ago. Every atom contains a small but massive atomic kernel, the nucleus, which itself is made of heavy particles closely bound together. Revolving about this nucleus are a number of light-weight particles known as electrons. Each of these two parts of the atom may be altered. *First,* the arrangement of the surrounding electrons may be changed; *chemical reactions* belong in this class of process. *Second,* the particles within the nucleus may be rearranged; such rearrangements are called *nuclear changes.* Whenever a change occurs, energy is either absorbed or released.

If the change is such that it makes the system more stable, energy is released—just as energy is released when a stone in an unstable position on a mountainside rolls to a more stable position farther down the slope.

Chemical reactions, as already stated, involve only rearrangements of the loosely-bound electrons in the outer part of the atom. Up to now, such changes have been the most im-

portant everyday source of energy. Some chemical reactions, such as the burning of coal, furnish great quantities of energy for industry. But the large amount of energy thus produced is due to the fact that countless billions of atoms react within a short time. The energy contributed by a single atom in a *chemical reaction* is very tiny in amount.

Nuclear changes are different. Here it is not the loosely-bound electrons which are shifting their positions, but the building stones of the nucleus. These are held together by tremendous forces, and consequently, even when they rearrange only slightly, the amount of energy released may be enormous. Perhaps the most familiar example of a nuclear change is that involved in radio-activity, such as occurs when an atom of radium shoots out an alpha particle. The energy released by a single atom undergoing a *radioactive change* is about *one million times* as great as the energy released by a single atom undergoing *chemical change.*

Still more powerful is the nuclear change known as *fission,* the process utilized in the atomic bomb. Here the nucleus is profoundly altered. It splits into fragments in such a way that the energy released is a hundred times as great as the energy released by a radioactive change. Thus, radioactivity produces a *million times* as much.

Part of the energy released by fission is in the form of powerful radiations. Moreover, the fragments of the split nucleus are not quite stable. They are therefore radioactive, and emit additional penetrating rays. These rays are dangerous. A man exposed even for a few seconds to those produced by a single unshielded nuclear power unit would surely die. That is why such a unit must be surrounded by walls several yards thick.

The destructive power of the radiations is easy to understand. When these radiations are absorbed by matter, their energy is taken up by the loosely-bound electrons responsible for the structure of chemical compounds. Thus, the radiation from a single disintegrating nucleus is sufficient to change the structure of hundreds of thousands of molecules. This process plays havoc with the delicately balanced chemistry of living tissues.

The radiations produced by fission, though dangerous, may nevertheless prove to be the most important gift of the new scientific development. A knife can be used not only to kill but to cure. The radiations from radium and X-rays are also dangerous, but the miraculous results achieved by using them against cancer are well known. Atomic power plants provide the means of magnifying and possibly of multiplying many times such applications in the treatment of disease.

Another by-product of an atomic power plant is an immensely increased supply of radioactive isotopes. Professor Urey explained the nature of isotopes last Sunday. As you know, they are atoms of the same chemical element which differ in atomic weight. Some isotopes are radioactive. that is, their nuclei are unstable, and may at any moment release radioactive energy. It is possible to produce a radioactive isotope of almost every chemical element. Carbon, iodine, phosphorus, and other elements which are natural constituents of our

bodies may thus be rendered temporarily radioactive. And while they are radioactive, they may be used in the treatment of disease.

The thyroid gland, for example, selectively absorbs from the bloodstream compounds containing iodine. So the attempt has been made to treat the thyroid disease known as goiter by introducing, into the body, compounds containing a radioactive isotope of iodine. Perhaps some day the same principle may be used to develop a successful treatment for cancer. The first step would be to find an ordinary chemical compound which is selectively absorbed by cancer cells. The next step would be to rebuild this compound, replacing some of the atoms in its molecules by radioactive isotopes. Such a project would require long and careful research, and I am certainly not suggesting that a cure for cancer lies just around the corner. All I wish to say is that we now have new and powerful tools to help in the never-ending war against disease.

Radioactive isotopes have also been used to trace the complicated sequence of chemical reactions which take place within the body. Consider, for example, the process by which sugar is used. Sugar serves as a fuel. In the body, it burns and yields energy—that chemical energy which was mentioned a few moments ago. But at body temperature, the ordinary process of combustion is too slow to maintain life. On the other hand, the body temperature cannot be increased without endangering life. So the combustion of sugar must somehow be accelerated at body temperature.

For this purpose, the body has developed a group of accelerators known as enzymes. Each enzyme molecule has a special task which it performs over and over again, like a workman on an assembly line. There are more than twenty enzymes engaged in the oxidation of sugar within the body. Some remove hydrogen atoms from the sugar molecules; others split off carbon dioxide. Thus, with enzymes serving as the activators of change, the process of breaking down the sugar and releasing its energy proceeds step by step.

It has been a long and laborious task to unravel this sequence of chemical changes by which sugar is burned in the body, but developments in this field have recently been greatly aided by the use of radioactive isotopes. The biochemists, by building radioactive carbon atoms into sugar molecules, have shown that the wrecking of these molecules is accompanied by combination of the fragments into new compounds. A similar technique has been very useful in exploring the method by which plants, under the influence of sunlight, produce sugar.

Here, then, are two benefits that we can confidently expect from the development of nuclear energy.

First, an enormously increased supply of radiation for the treatment of diseases; *second,* a prolific source of radioactive isotopes for use both in medical therapy and in biochemical research. And there are other possibilities. As a matter of fact, the new sources of atomic energy offer so many opportunities for advance that we are now facing *the dawn of a new era in chemistry and biology.*

The Atomic Age

by J. Robert Oppenheimer

Official head and inspiring leader of the atomic bomb laboratory in New Mexico, Dr. Oppenheimer, who was born in New York and trained at Harvard and in Europe, has taken a prominent part in discussions of the impact on society of problems raised by the atomic bomb.

➤ In the hour before dawn one day last summer, the hills of the Jornado del Muerto, a desert stretch in New Mexico, were briefly lighted with a light no man had ever seen before. We who were there knew that a new world lay before us. It is my privilege today to say a few words of what is discernable to us in the outlines of this new world.

Let me be clear on one point: no great new principle of nature was discovered or revealed in that first atomic explosion. The bomb which we there tested was based on the broad foundation of a century of physical science. In its design were embodied the great principles of the behavior of radiation and matter, as they were worked out in the closing years of the last century and in the first three decades of this. Into this bomb was built the experience of the world's laboratories on atomic nuclei and their reactions. It had been discovered, only a few months before the outbreak of the war, that a neutron could induce the fission or splitting of the heaviest nucleus into two almost equal components. This break-up of the nucleus was accompanied by the liberation of a large amount of energy, and also of enough neutrons to cause this fission to spread to more and more nuclei, if the material and circumstances were right. Our job in the war projects was to make the circumstances right.

If there was any surprise in this first explosion, it lay not in any great new discovery. It lay rather in the fact that what happened was so like what we thought would happen—that the physical science which had been built into this new weapon was such a sure and reliable guide.

With trivial exceptions, all the power that is used on earth derives from nuclear reactions which take place in the sun. The nuclear reactions which took place in the New Mexican desert were of a different kind, and are subject in quite a different way to man's control.

It seems to be a general impression that there are serious and fundamental problems in controlling the release of this energy and in making it useful for the purposes of society. This view is based on misconception. More than two years before the test in New Mexico, another great experiment was carried out at the Metallurgical Laboratory in Chicago. In this experiment, conditions were so arranged that the fission of one uranium atom in a great mass of uranium and graphite produced, through the neutrons it generated, the fission of a second atom, and so on indefinitely. The experiment could be run with the rate of fission and the rate of energy release adjusted within wide limits by a simple control. This was the first self-sustaining fission chain reaction.

Since then many varied devices have

been designed and built, each of them generating appreciable quantities of energy, all of them based on maintaining a controlled nuclear chain reaction. Some are small, some enormous; and the power which they generate also varies by large factors: but all were made as a part of the program of developing atomic bombs and all have one feature in common: they do not develop energy at a high temperature.

The technological problem of operating such units to produce energy at a temperature high enough to make it profitable to generate electrical power, or to provide steam for heat or for industrial uses, appears to be capable of solution in many ways in the very near future. We see no real limitation on the availability of nuclear fuel. Therefore we may look confidently to the widespread application of such sources of power to the future economy and technology of the world.

One word of warning may be appropriate: a unit of this kind, operating, let us say, at a thousand kilowatts, produces radiations roughly equivalent to those from ten tons of radium. If men are to be anywhere around such units, this radiation must be absorbed by shields of very appreciable bulk. For this reason alone, we do not think automobiles and airplanes will be run by nuclear power units—not, at least, until a new idea supplements our present knowledge.

But the fact that nuclear-energy units require an insignificant amount of fuel makes us think that they will be applied to extend the present uses of power in our economy. We do not expect petroleum or coal to become outmoded as fuel. It is clear that although useful power plants may be only a few years away, the full adaptation of the new possibilities to a living economy will be a matter of many more years than that.

Most scientists see one of the greatest benefits of the atomic age in just those radiations and radioactivities which made the power plants so intractable. These agencies hold particular promise in the fields of biological, biochemical, and medical studies, where they should provide tools of immense power, both for the treatment of disease and for the attack on fundamental problems.

Only time and work can show if these hopes are justified. Even for the field of physics there will be new possibilities. I may give one example: the neutron is a constituent of atomic nuclei, but it does not occur free in nature, where its properties can be studied. Neutrons do occur in great numbers among the fragments of the chain reacting systems, and it is there that their somewhat unfamiliar behavior will best be explored. Of this whole field of research we see very much less than the mariner sees of the iceberg. That is what is meant by research.

The explosion in New Mexico was neither a controlled source of power nor a research tool—it was a weapon. Within a few weeks it was to be a weapon used against human targets in the strikes against Japan of August 6th and 9th. Today this is the aspect of the atomic age which is most prominent—and most rightly prominent—in all our thoughts. There does not seem to be any valid doubt that atomic weapons can be made, made

plentifully, made cheaply, and indeed be made very much more destructive than the one we tested in New Mexico. There does not seem to be any valid hope that defenses against such weapons can be made effective against attack based on surprise, or that specific defenses against such weapons, other than the destruction of enemy bases and enemy carriers, will be developed in the future. There is, to my mind, little valid foundation for the belief that in a world torn by major wars these weapons, for tactical or humane reasons, will be left unexploited.

Often before men have claimed that a weapon had been found so terrible that wars would cease; often before men have pointed to the increasing technical and social interdependence of the peoples of the world and argued that wars should cease. The fact that these arguments have not prevailed does not mean that they will not prevail today. The fact that increasingly terrible wars have been waged does not mean that we should prepare to wage still more terrible ones in the future. It is not in this sense that history is to be read. For this is what is now in the atomic age: a world to be united, in law, in common understanding, in common humanity, before a common peril.

War Stopped Basic Research

➤ POST-WAR EXPANSION of industrial research by small companies will be limited by scarcity of scientific and technical men, reports R. J. Dearborn, president of Texaco Development Corporation.

"One of the most serious problems of industry is the deficit in fully trained young professional men for postwar employment," Mr. Dearborn declared. "This country is faced with a period during which the demands of war-stimulated technology will not be met by an adequate supply of scientists and engineers. As research is the backbone of industrial progress and creation of jobs in the postwar era, the lack of a sufficient number of well-trained scientists will have a profound effect on invention and plans of corporations to provide for many new products."

War has prevented the normal flow of trained young men from the colleges, and a great number of trained men, in the armed services and in war jobs, will find it difficult to return to their old work due to disuse of their technical abilities, he pointed out. Training of scientists in the colleges had almost come to a standstill, and it will be 1950 before a normal flow of technical graduates can be expected.

Government will probably continue to compete with industry for scientific personnel, Mr. Dearborn stated, since the government will probably intensify its research activities. In addition, there will be a great demand for United States technical personnel abroad, due to the tremendous reconstruction work which will be needed. Still other trained persons will go to colleges and universities as teachers.

Inventions Recognized
By U. S. Patent Office

Chemical Progress In Patents

For a dime, the specifications of any new invention can be obtained as part of the quid pro quo for the patentee's 17 year right to his brain-child. Order patents by number from the Commission of Patents, Washington, D. C., remitting by Patent Office coupon, cash or check (not postage stamps).

Addition to Tobacco

➤ SOMETHING new really has been added to smoking tobaco — and smokers who have tried it have unanimously expressed a preference for it, even without the ritual of a blindfold test. For this simple addition of something that makes tobacco taste better when smoked, three chemists, Dr. C. F. Woodward, Dr. Abner Eisner and P. G. Haines, at the U. S. Department of Agriculture's regional laboratory at Philadelphia, have received U. S. patent 2,392,514 assigned, royalty-free, to the Secretary of Agriculture.

Actually the "something new" has been in tobacco smoke all along, though it has never been found in tobacco itself. It is an alkaloid known as myosmine, which is said to be responsible for the pleasant aroma of cigar smoke, and which can now be produced synthetically.

The three chemists added microscopic quantities of myosmine to cigarettes, cigars and pipe tobacco, and then invited smokers to compare the treated smokes with similar ones that had no added myosmine. Without exception, the smokers liked the treated tobaccos better.

Sulfite Liquor Used

➤ ONE OF INDUSTRY'S worst waste-and-pollution problems, disposal of sulfite liquor from paper and wood-pulp mills, is attacked from a new angle by Richard G. Tyler of Seattle, who has been granted patent 2,392,435 on the process he has worked out. Instead of trying to reduce the volume of the lime sulfite solution directly by evaporation, and thereby running into scale-formation trouble, he puts the spent liquor through a carbonaceous base-exchanger which has previously been treated with a solution of common salt—sea water will do.

The solution comes out as a complex mixture of sodium salts, containing lignin and other residues of the wood. After evaporation this can be burned under the boilers, supplying power. The clinker or "smelt" that is left is rich in commercially valuable sodium salts.

Simplified Lead Smelter

➤ A SIMPLE, compact and portable machine for extracting lead from its sulfide ores is the subject of patent 2,392,526, obtained by Orville V. De Shazo of Wichita, Kans. A metal conveyor belt carries the powdered ore under a dome-shaped heat reflector, where a series of acetylene flames strike it. The lead melts out

and falls into a series of refractory-lined molds moving on a second conveyor. By the time the molds have reached the end of the conveyor the lead has hardened into pigs, and as the molds run over the end and turn upside down the lead pigs fall out. The powdered slag is blown away by a fan.

Cashew Paint Remover

➤ A PAINT AND VARNISH remover is made from the hulls of cashew nut shells. The liquid extracted from these shells contains an acid, known as anacardic acid, which the inventor, R. E. Sadtler, of Ridley Park, Pa., states will loosen paint or varnish in 15 or 20 minutes. Patent 2,392,699 has been issued on this liquid.

Mottled Ice Cream

➤ A PROCESS for making mottled ice cream, on which patent 2,392,698 has been granted to N. J. Russell of Wauwatosa, Wis. The half-hardened ice cream, as it flows from the freezer, is passed through a narrow trough where it is pushed along by a screw. At this point suitable coloring additions, like chocolate fudge, can be poured in, and the mixing effect of the screw will distribute it fairly uniformly as attractive mottlings or marblings.

De-Leading Leaded Gasoline

➤ A WAR-BORN invention is a method for freeing gasoline of poisonous tetra-ethyl lead, so that it can safely be used for cooking fuel, cleaning fluid, etc. This was of especial importance during the war, since it was impracticable to supply "straight" unleaded gasoline separately.

The new de-leading method was developed by George Calingaert, Harold Soroos and Hymin Shapiro, all of Detroit. It consists in adding the very common chemical salt, stannic chloride, to the leaded gasoline. The reaction produces a mixture of di-ethyl lead chloride and di-ethyl tin chloride, both of which are insoluble in gasoline. Water is then added, to collect the precipitates, and after the gasoline has been well stirred and permitted to settle, it is decanted or siphoned off from above the watery sludge, safe for human contacts.

Rights in the patent, No. 2,390,988, are assigned royalty-free to the government.

Pipes for Explosives

➤ A PAIR OF Scotsmen, George Bryce of West Kilbride and V. H. Williams of Ardrossan, have received U. S. patent 2,391,006 on a safety pipe-line for conveying nitroglycerin and other liquid high explosives. To prevent an accidental detonation from propagating itself along a solid pipe-line back to the main works, they interrupt their line with well-and-siphon arrangements at intervals, so that an explosion can blow out only one length. Patent rights are assigned to Imperial Chemical Industries, Ltd.

New Fluorescent Lamps

➤ THE WESTINGHOUSE Electric Corporation is assignee of two new patients on lamps, Nos. 2,392,305 and 2,392,333 respectively. The first is on a high-efficiency fluorescent lamp, developed by Dr. N. C. Beese of Verona, N. J. It is shaped like the ordinary incandescent bulb and utilizes arsenic instead of mecury to produce the ultraviolet radiations that produce visible light when they strike the

phosphor minerals distributed on the inside of the outer glass envelope. With the use of zinc cadmium sulfide as phosphor, a continuous spectrum, closely approximating daylight, is obtained. Another advantage is efficient operation over a wider temperature range than is possible with the familiar mercury lamps.

The second lamp, devised by Chalmers Morehead of East Orange, N. J., is a new fluorescent bulb for Christmas-tree illumination. This little lamp is cooler in operation, and hence consumes less current; it gives more pleasing color effects than are obtainable with colored glass or filters; finally, if one unit burns out it does not extinguish the whole series, as is the case with the older incandescent Christmas-tree lamps.

Machinable Insulators

➤ MOST FAMILIAR insulators are made of glass, porcelain or other material that cannot be turned on a lathe or bored with a drill. A. J. Monack of Rutherford, N. J., offers as a machinable insulating composition a mixture of a titanium compound, mica and a frit consisting of a metallic borate, as subject for patent 2,391,376. Rights are assigned to the Mycalex Corporation of America.

White Lead Pigments

➤ IN PLACE of time-honored lead oxide, or white lead, two new lead compounds have been produced for paint pigment and other uses. These are lead silicate, on which Louis E. Barton of Windsor, Conn., has received patent 2,391,118, and lead salicylate, on which patent 2,391,166 has been issued to Leonard M. Kebrich of Brooklyn, assignor to the National Lead Company.

Aluminum Defect Detector

➤ ALUMINUM CASTINGS and forgings sometimes have finer-than-hair cracks or other defects in them that defy ordinary methods of inspection. To spot these flaws is the object of a method developed by Charles J. Slunder of Columbus, Ohio, to whom U. S. patent 2,391,522, assigned to the Aluminum Company of America, has just been issued here.

The aluminum objects are first cleaned, especial care being taken to rid them of oil and grease. Then they are dipped for about a minute into a solution of hydrofluoric acid, of from 2.5% to 5% strength. This penetrates into the invisible cracks and forms compounds there that can take and fix organic dyes. After immersion in a dye bath and rinsing the excess off the surface, the castings show up any cracks as strongly contrasting lines of red, blue or other color on the silvery white of the aluminum.

Aluminum Scrap to Rods

➤ ANOTHER PROCESS that has to do with aluminum is the subject of patent 2,391,752, obtained by Max Stern of Kew Gardens, N. Y. Mr. Stern undertakes to make small aluminum scrap, borings, etc., directly into rods and other forms, without melting it down into ingot form. This he accomplishes by putting the well-cleaned scrap into a massive press, where it is heated to relatively moderate temperatures (350 to 450 degrees Centigrade), but subjected to the enormous pressures of from 18 to 40 tons per square inch. Under these conditions the separate bits of metal flow together into a homogeneous

solid, as snowflakes are converted by pressure to the solid ice of glaciers.

Whey in Soft Drinks

➤ WHEY, TRADITIONALLY the delight of such innocents as Miss Muffet and Old Grimes, may presently be the means of putting a most beery-looking "collar" of foam on non-alcoholic beverages, under a process on which patent 2,391,559 has been granted to June E. Faulkner of Chicago. This watery-looking by-product of the cheese industry contains proteins and other colloids that make a good, substantial, creamy foam after the raw whey has been cleared of objectionable materials and rendered chemically neutral.

Interior Photography

➤ COLOR PHOTOGRAPHS of the lining of your stomach or other parts of your interior may be made by means of a special flash-lamp invented by Franz G. Back of New York. A single, fusible filament furnishes the maximum of illumination with practically no heat, when a suitable charge has been built up on a special condenser. A miniature camera, lowered along with the lamp, gets the picture. Rights in the patent, No. 2,391,611, are assigned to the Gastro-Photor Laboratories Corporation.

Lignin for Leaks

➤ USE OF LIGNIN, that eternal Cinderella in the wood-pulp industry, is in a leak-sealing compound for radiators, boilers, etc. The calcium salt of ligno-sulfonic acid is mixed with ground asbestos and water in the formula on which Arthur C. Pabst of Douglaston, N. Y. obtained patent 2,391,737, rights in which are assigned to Socony-Vacuum Oil Company, Inc.

Transporting and Drying

➤ A METHOD FOR simultaneously transporting and drying crystals of ammonium sulfate is by blowing them through a duct with a blast of hot air. Caking of the product, a perennial trouble with this salt, is thereby avoided, states the inventor, William Seymour of Sault Ste. Marie, Ont., who has assigned rights in his patent, No. 2,391,484, to the Koppers Company, Inc.

Super-Abrasive

➤ A SUPER-ABRASIVE compound for wheels or other cutting or grinding tools is made by embedding industrial diamond particles in a matrix which is itself highly abrasive, preferably the carbide of boron, silicon, zirconium, nickel, chromium or iron. This development of an inventor in England, Leon Nussbaum of London, is covered by patent 2,391,589.

Light-Filtering Paint

➤ A LIGHT-FILTERING coating for lamps—in effect a light-filtering paint—is covered by patent 2,392,095, issued to Eugene Lemmers of Cleveland Heights, Ohio, and assigned to the General Electric Company. Its object is to get a light-filtering coating that will be more stable than the colored gelatins often employed, and at the same time less cumbersome and costly than the solid glass filters also used.

The vehicle for the new paint-filter is polystyrene dissolved in butyl acetate, with dry ground glass added to give it body. The actual light-filtering particles, taking the role played by pigments in conventional paints, are made of the oxides of arsenic, aluminum, calcium, and other elements.

Sulfathiazole Purification

➤ A LOWER-COST method for purifying sulfathiazole promises to make this valuable germ-stopper available at lower prices. The new method, developed by L. H. Dhein of Bound Brook, N. J., is protected by patent 2,392,125, which has been assigned to the American Cyanamid Company.

Instead of the costly decolorization with subsequent recrystallization from organic solvents now in use, the new method consists in adding concentrated ammonia water to the crude drug, mixing with a solution of decolorizing carbon and filtering, then distilling off the ammonia under vacuum. The sulfathiazole comes out as a clean precipitate, which after further washing is dried and prepared for market.

Tomato Products Patents

➤ Two NEW PATENTS are on tomato products. The first, covered by patent 2,392,197, granted to H. L. Smith, Jr., W. E. Conley, Jr., and W. L. Atwood, all of Richmond, Va., is a method for continuous flash-sterilization of tomato juice, which is then filled directly into cans.

The second patent, No. 2,392,241, is on a process for rapid dehydration of tomato juice into powder form, by spraying it into a steam-heated chamber, then rapidly cooling it. The inventor, E. F. Glabe of Chicago, has assigned rights to Stein, Hall and Company.

Reclaiming Caffein

➤ A MORE ECONOMICAL way of reclaiming the caffein extracted from decaffeinated coffee is the contribution of Roland E. Kremers of Summit, N. J., for patent 2,391,981, assigned to the General Foods Corporation. Instead of boiling all the water or other solvent off, Mr. Glabe shakes the caffein solution with fine clay, which adsorbs the drug. Then it is re-dissolved with another solvent.

Soaps, Finer and Shinier

➤ FINER SOAP powders may be prepared by the method on which patent 2,392,072 was issued to Alfred Vang of New York. He flows a slow stream of melted soap onto a rapidly vibrating diaphragm, which bounces it into the air in small particles that harden before they fall. A fan blows them away, and they fall into bins, automatically assorted by weight, and hence by size.

Another patent that has to do with soap is No. 2,391,919, granted to an Englishman, Thomas Penny of Bebington, assignor to Lever Brothers Company. It is a process for imparting a glossy surface to bars of soap by subjecting them first to jets of hot steam, then to drying air blasts.

Answers to Chem Quiz on Page 32.

➤ ACETAMIDE CH_3CONH_2 smells like mice; amyl acetate $CH_3CO_2C_5H_{11}$ bananas; amyl valeriate $C_4H_9CO_2C_5H_{11}$ apples; benzaldehyde C_6H_5CHO almonds; ethyl butyrate $C_3H_7CO_2C_2H_5$ pineapples; ethyl formate $HCO_2C_2H_5$ peach kernels; ethyl sulfide $(C_2H_5)_2S$ garlic; methyl cinnamate $C_6H_5CH \cdot CHCO_2CH_3$ strawberries; methyl salicylate $OHC_6H_4CO_2CH_3$ wintergreen; phenyl acetaldehyde $C_6H_5CH_2CHO$ hyacinths.

Strange Earths Yielded New Elements
From a Rare Black Mineral of Ytterby

Discovery of the Rare Earths

A Classic of Chemistry

➤ UNFOLDING the mystery of the rare earths has required a century and a half, and it is by no means certain yet that their complete tale is told. Some of the steps in the discovery and disentangling of yttrium and its associates are given here. In later issues classics of discovery of other groups of these confusing elements will appear. It has been the aim of the editor to present the shifting viewpoints of the men who worked on the rare earth minerals, and something of the methods they used, rather than detailed accounts of the experiments they performed. The literature of the tests is bulky, but relatively easy of access to analysts who wish to work with these fascinating but time- and patience-consuming minerals.

A New Mineral

VON EINER SCHWARTZEN, SCHWEREN STEINART AUS YTTERBY STEINBRUCH IN ROSSLAGEN IN SCHWEDEN. *(On a black, hard mineral from Ytterby quarry in Rosslagen in Sweden). By Prof. J. Gadolin*. In Chemische Annalen (Crell) Vol. 1. Helmstädt (Germany)* 1796. *Translated by Helen M. Davis.*

➤ THIS MINERAL, noteworthy on account of its unusual weight, was first discovered by Capt. Arrhenius in Ytterby quarry, ¼ mile from Warholm Castle, where a white feldspar is dug for the Stockholm porcelain factory . . .

From its properties one finds that this earth agrees in many ways with alumina, but in other ways with lime, so that it is distinguished from both, even as much as from the other, already known earths. Therefore it seems to deserve a place among the elemental earths, because the tests so far made do not allow grouping with any others. At the present time I dare not claim such a new discovery, because my small supply of the black mineral does not allow me to carry out the research according to my wishes. Apart from that, I hesitate also for this reason, that much more knowledge would be gained if the several new earths, recently described by the analysts, could be decomposed into their elemental constituents, as then the number of the new simple earths will be still further increased.

*The foregoing communication was accompanied by a letter to me, dated July 3, 1794: but both came first to my sight on the 26th of March of this year [1796], as I can vouch for truthfully. The most plausible explanation of this seems to be, that the letter was put in charge of a traveller on a journey, so that, perhaps through various circumstances, it may have lain overlooked for a long time. While lost, the paper has not been given the consideration for which it was prepared, so several explanations are due Prof. Klaproth's excellent contribution. —C.

A New Earth

Fernere Untersuchungen der Schwarzen Steinart von Ytterby und der in Derselben Gefundenen Eigenthumlichen Erde. *(Further Investigation of the Black Mineral from Ytterby and the Peculiar Earth found in it). By A. G. Edeberg. In Chemische Annalen (Crell). Helmstädt (Germany),* 1799. *Translated by Helen M. Davis.*

➤ Prof. Gadolin, in the Transactions of the Royal Academy of Sciences (Stockholm) for the year 1794, second quarter, has described an investigation of a black mineral from the Ytterby quarries in Rosslagen, and at the same time the announcement of the chemical analysis by which he accomplished the discovery of a new and hitherto unknown earth. It seemed necessary to determine the properties of this earth, in order to decide upon its identity and its differences from those already known. Yet with the caution which only older and more experienced analysts have, it was given a place as a true earth, without any reservation or more exact knowledge. Upon getting the opportunity, I have also subjected this material to analysis, and there seems to me no longer any doubt that it should have this place.

Captain Arrhenius, whose enthusiasm for science gave Prof. Gadolin the opportunity to investigate this material, is also the one who has put me in the way of being a collaborator in the discovery. Such a beautiful piece of the mineral was sent me by him that after breaking it up I could select little pieces free from feldspar for analysis. Since Prof. Gadolin did not have this advantage, the proportion of constituents in my determination must naturally be somewhat different from that given by him. For it is clear, that the included feldspar would increase the percentage of silica and alumina, at the expense of the other substances.

Upon a weighed sample of the mineral was poured 16 times as much pure muriatic acid, and the mixture was held at gentle ebullition until the soluble part was extracted, and the clay remained as a white, cheesy mass. After drying and ignition, this weighed 25 parts, and with soda gave a glass bead before the blowpipe, which remained clear upon cooling.

From the filtered solution, which appeared lemon yellow in the cold and bright green when warm, there was precipitated with caustic sal volatile (ammonium carbonate) a dirty-brownish earth. After this was separated by filtration, the liquid gave no precipitate with carbonated sal volatile, and yielded upon evaporation pure sal ammoniac (ammonium chloride). The reserved dirty precipitate, while still moist, was put into a caustic potash solution and heated with it for some time, when the insoluble part was separated.

The potash-soluble part was saturated with nitric acid, which made it turbid, but it was cleared again by an excess of acid. It was then precipitated with carbonated sal volatile, and the alumina thus obtained weighed, after ignition, only $4\frac{1}{2}$ parts.

What was left from the potash solution was dissolved in dilute sulphuric acid. After evaporation to dryness, the residue was strongly ignited, until it had taken on a red color through and

through. Then it was digested with water and filtered, when a bright red iron ochre remained on the filter paper, which, after strong ignition weighed 18 parts. The reason for this procedure is easy to see. The sulphuric acid solution contains the new earth, together with iron, and the question is, how can they be separated from each other? This, I thought, could most conveniently be done by ignition, because vitriol loses its acid thus, and, by analogy, it was to be expected that the compound of the earth with sulphuric acid would remain undecomposed, which indeed occurred.

The filtered solution was slowly evaporated, and it appeared that the compound of the earth with sulphuric acid could crystallize into beautiful crystals, of which the most conspicuous were nearly half as large as raisin seeds. As the solution shrank, the crystals became finer and the form less easily distinguished, until the last looked just like a powder. After all the salt was dissolved in water again, the earth was precipitated with carbonated sal volatile, ignited and weighed. It was found to amount to 47½ parts . . .

From the experiments which I have made with the earth, I will, to avoid diffuseness, omit those which agree with Prof. Gadolin's own, and merely state those which I regard as contributing to further description of the material.

All moistened and dissolved compounds of this earth with an acid have a very sweet taste, like solutions of lead, not so unpleasant but more sharp and astringent. Its compound with acetic acid is, in my opinion, fully as sweet as sugar of lead . . .

I find nothing to hinder me from believing that the properties and characteristics of this earth are just as well defined as those of any hitherto known; as proof I will enumerate several especially striking reactions by which this substance can be distinguished from others. It is distinguished from barytes in that it gives a soluble salt with sulphuric acid, and can not be made to crystallize with nitric and muriatic acids. From lime by its crystals with sulphuric and acetic acids. From magnesia in the same way, and from all three by this, that they are precipitated by caustic sal volatile. From alumina, in that it is not dissolved by caustic potash lye, and gives with acetic acid a salt stable in air. From silica, aside from its solubility in acids, because it can be dissolved again from the ignited carbonate in the wet as well as in the dry way. . . . Its reaction with carbonic acid differentiates it from zircon, not to mention its taste and the crystals of its neutral salt. It cannot be confused with strontia, which forms a most difficultly soluble compound with sulphuric acid, and one capable of crystallization with nitric and muriatic acids. Also it does not correspond especially with *Australerde,* which can be dissolved in no acid except muriatic, and in that not without boiling. It thus takes its proper and deserved place in the system of neutral elements, as a simple and independent earth.

It must therefore be named, and it seems most fitting that it should be named from the place where it was first discovered, because neither the name of the discoverer nor that of the mineral are sufficiently short for forming a name for common speech. But it can be called Ytter-earth, in Latin

Yttria, which is free from all ambiguity and confusion both in meaning and spelling. The mineral itself should no longer be called pitchstone, for that has an entirely different meaning, since substances dug up elsewhere are so named, but it should be called *Ytterstein.*

In regard to the opinions as to the use of the discovery of a new earth, I cannot quite agree with Prof. Gadolin, for Yttria has such clear and definite properties. By complicated and troublesome investigation it may be possible at another time to achieve much understanding and profit. Is baryta not indispensible now in manufacturing many substances, and necessary in analysis, and what need does it not fill in medicine! That Yttria, whose acid solutions have such a characteristic taste, may also find a use in medicine is perhaps not such an untruthful possibility.

What may be discovered through further research upon the nature of this earth and its behavior toward other bodies, I leave for the future to show.

Cerium

New Earth. *Note in Philosophical Magazine, Vol. XIX, London: 1804.*

➤ Klaproth has discovered a new earth in an ore which has hitherto been supposed to contain tungsten. He has given it the name of *ochroit* earth. It seems to form the connecting link between the earths and the metallic oxides. It produces, like yttria, a reddish-coloured salt with sulphuric acid, and is precipitable by all the prussiates; but it differs from yttria in not forming sweet salts, in not being soluble in carbonate of ammonia (or but little so), and in acquiring, when ignited, a light brown colour. It also differs from yttria by not being fusible either by borax or by phosphates, with which yttria fuses into a colourless transparent globule.

On cerium, a new metal found in a mineral substance of Bastnas in Sweden, called Tungsten, *described by W. D'Hisinger and J. B. Berzelius. In Philosophical Magazine, Vol. XX, London: 1805.*

➤ Though this substance was formerly tried by Scheele and D'Ellhuyar, under the name of wolfram, yet its considerable specific gravity determined us to subject it to further researches. Our object in particular was to find yttria, which, being unknown at the time when these chemists carried on their labours, might have escaped their attention. Our suspicions were ill-founded; since, instead of an earth, we found in it, according to every appearance, a substance hitherto unknown, as will be seen by what follows:

(A lengthy account of the various reactions to which they subjected the substance follows).

These and the following circumstances have determined us to consider the substance found in cerite as the oxide of a metal hitherto unknown, to which we have given the name of *cerium*, from the planet Ceres discovered by Piazzi.

Method for Oxide of Cerium

(A.) Dissolve pure cerite, not calcined, in nitr-muriatic acid, and, hav-

ing saturated the clear solution with alkali, precipitate it by tartrate of potash. The precipitate, when well washed, calcined, and digested in vinegar, contains pure oxide of cerium.

Or decompose a solution of cerium in nitr-muriatic acid, still warm, but not saturated by succinate of ammonia: a succinate of iron is gradually deposited. Continue this precipitation by muriate of ammonia until a white precipitate appears. Leave the solution at rest, in order that the small portion of succinate of cerium may be deposited. The iron dissolved by the free muriatic acid deposits itself at the same time, and the solution is obtained free from that metal. You may then precipitate the cerium with ammonia, and wash and calcine it.

Rival Claims

ACCOUNT OF EXPERIMENTS MADE ON A MINERAL CALLED CERITE, AND ON THE PARTICULAR SUBSTANCE WHICH IT CONTAINS, AND WHICH HAS BEEN CONSIDERED AS A NEW METAL. *By M. Vauquelin. In Philosophical Magazine, Vol. XXII, 1805.*

➤ M. KLAPROTH wrote to me, about eight months ago, that he had discovered, in a mineral of Bastnaes, in Sweden, a new earth to which he had given the name of *ochroit,* on account of the red colour which it assumes by calcination. He even sent me in a letter a small specimen of this substance; and having discovered in it, by several trials, the presence of a considerable quantity of oxide of iron, I started some doubts, in a note which I read in the Institute, in regard to the colour of that earth. I observed also in the same note, that this substance had as many metallic properties as earthy characters; but that the small quantity of it which I had in my possession did not allow me to give any decisive opinion on this subject.

Some time after, Messrs. Berzelius and Hisinger, having been informed, by their correspondents at Paris, of M. Klaproth's labour, wrote to me to claim a priority, stating that they had sent to M. Klaproth the specimens of that mineral which he had employed for his experiments, and that at the same time they had announced to him that they had found a new metal in it. I can give no opinion on this difference. I shall only observe, that the well known delicacy of M. Klaproth, and the high reputation he has justly acquired by his numerous and important discoveries, render it very improbable that he would appropriate to himself the discovery of another. M. Klaproth must, no doubt, have received from another quarter the mineral in question; and his labour was perhaps terminated before he acquired any information respecting that of the Swedish chemists. What seems to justify this opinion is, that they obtained results entirely different.

Every thing, therefore, seems to show that M. Klaproth of Berlin, and Messrs. Berzelius and Hisinger of Stockholm, made experiments at the same time on the mineral without having any comunication with each other; and that each may have had the honour of the discovery.

Who's Who in This Month's Classic

JÖNS JAKOB BERZELIUS (1779-1848) was the great Swedish chemist who determined the atomic and combining weights of many elements. He is chiefly responsible for making oxygen the standard element for atomic weight. He also invented our system of abbreviations as chemical symbols, and our method of writing chemical equations.

LORENZ FLORENZ FRIEDRICH VON CRELL (1744-1816) was a German chemist, Professor first at Braunschweig (Brunswick), then at Helmstädt, finally at Göttingen. While at Helmstädt he edited a series of journals which chronicled the rapid advances of chemistry.

JOHANN GADOLIN (1760-1852) was the son of a famous Swedish astronomer. Himself a chemist, he is famous for his discovery of the black mineral at Ytterby from which the first and so many of the other rare earths were extracted. One of these new elements was later named for Gadolin by its discoverer, Marignac, in 1880.

WILHELM HISINGER (1766-1852) was a Swedish chemist who worked with Berzelius on a number of problems in chemistry and electricity. They discovered cerium in a mineral which had mistakenly been considered a tungsten ore.

MARTIN HEINRICH KLAPROTH (1743-1817) was a famous German chemist who did much toward working out the composition of many substances. He discovered the elements uranium, zirconium and titanium.

LOUIS NICOLAS VAUQUELIN (1763-1829) was a French chemist noted for a vast amount of analytical work on many substances. He discovered the elements beryllium and chromium.

Yeast Hybrids Improve Diet

➤ HYBRID YEAST species are the newest products of plant breeders' efforts. They have been bred for the same reason that induced the production of hybrid varieties of tomatoes, sweet corn or any other of the more easily visible vegetables—to improve their usefulness in the human or farm-animal diet.

Yeast, taken either "raw" or processed, is usually eaten primarily for the sake of several vitamins of which it normally constitutes a highly concentrated source. Although the yeast plant consists of a single cell visible only through the microscope, yeasts are as individual in their characters as larger plants, and a number of botanically distinct species are recognized.

Some of these species, though good suppliers of certain vitamins, are poor or even completely lacking in others. For this reason Dr. Carl C. Lindegren and Gertrude Lindegren, botanists at Washington University, St. Louis, have interbred the various species, producing hybrids with more varied vitamin-producing capacities than any of the parents.

—Photo from Westinghouse

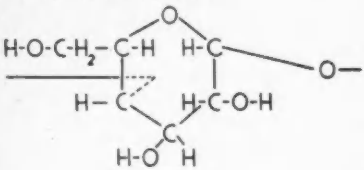
➤ DESIGNED *for beach-head use, this complete antenna unit weighs only 400 lbs. and is packed in four 100-lb. cases. It is another example of the utilization of light-weight alloys.*

Third of a Series on
The Chemistry of Foods

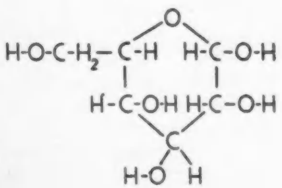
The Uses of Starch

by Helen M. Davis

➤ Starch is $(C_6H_{10}O_5)_n$. The *n* stands for a very large number. But the structure of the molecule is believed to be represented correctly by the formula. Each $C_6H_{10}O_5$ group forms a ring, similar to the ring structure of the sugars. Then the rings are strung together by oxygen atoms to form long chains, with some side chains of similar units.



starch unit



glucose unit

1.

The structural formulas of sugar and starch units show how similar the ring structures of these two carbohydrates are. The equivalent of one molecule of water is actually as well as empirically the difference between them. It is easily added, changing starch to sugar. Nature uses enzymes to carry out the reaction.

Enzymes are rather mysterious protein-like substances, too complex to be exactly chemicals, too simple to be living cells like yeasts or bacteria. Their behavior is much like that of catalysts, which take part in chemical reactions but emerge at the end the same in kind and amount as they were at the beginning.

Enzymes are responsible for many of the processes of food digestion. The digestion of starch begins in the mouth with the enzyme *ptyalin* which occurs in saliva. Ptyalin converts starch to maltose, which seems to be the usual product of starch-splitting enzymes. (To perform this experiment, eat a soda cracker slowly and note the appearance and increase of the sweet taste). Starch-splitters as a class are called amylases: *amyl-* from the Latin name for starch, *-ase* the general ending for names of enzymes. Specific enzymes are named for the reactions they promote. The one which changes maltose to glucose, the form of sugar directly assimilated by the body, is called maltase.

Amylases are of two types. One characteristically liquefies the paste which forms when starch is cooked. Starch-liquefying enzymes are called α-amylases. They are believed to unhook the web of interlocked starch units and break them up into sugar-like molecules. The other kind of

starch-splitter, like maltase, which attends to the addition of hydrogen and hydroxyl groups, belongs to the class of β-amylases.

Beside liquefying and sugar-producing reactions resulting from enzyme action, starch can be made to undergo another kind of "degradation" known as dextrinization. Dextrins are formed when starch is heated dry, usually after treatment with dilute mineral acid. They vary from colorless to dark brown, depending on the amount of heating. The dark kinds are known as "British gums." They approach in properties the natural plant gums such as gum arabic.

Dextrins and gums are used principally as adhesives. When you lick envelope flaps, stamps, labels and stickers you are quite likely to be licking a dextrin product, particularly if the adhesive has a sweetish, rather pleasant taste. Stickiness is one of the starch characteristics. Oddly enough it is increased by compounds of boron, as you can easily see by stirring a little borax into cooked starch paste.

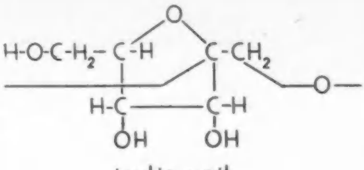
Another well-known property of starch is the stiffening it gives to cloth. In the manufacture of textiles, the warp threads are often starched to prevent wear and breakage in the weaving process. This starch coating must be removed by washing or by enzyme action before the cloth is printed. A second starching may then be given as part of the finishing process.

Adhesives and cloth stiffening are developments of the property starch has of thickening when cooked. This phenomenon, which is so familiar to the housewife, is the object of a good deal of study by chemists. They would like to understand exactly what goes on at the molecular level at each stage of the process. The smooth finish that comes from running a hot iron over starched material is believed to be due to formation of a transparent dextrin on the surface.

Starches of commerce come largely from corn and the other cereal grains, but also from potatoes and sweet potatoes and from the cassava or tapioca. As an interesting example of carbohydrate cookery on the manufacturing scale we give here a cookie recipe, with the familiar directions: "cream sugar and shortening together, add eggs, add water, add starch and flour." Quantities:—

100 lbs. flour
20 lbs. starch
50 lbs. sugar
17 lbs. dextrose
33 lbs. shortening
5 lbs. dry skim milk
10 lbs. eggs
1 lb. soda
½ lb. cream of tartar
½ lb. ammonium bicarbonate
1 lb. salt
65 lbs. water

Typical starches form the well-known blue color with tincture of iodine. Some related carbohydrates, such as dextrins, form similar compounds with violet, reddish or brownish colors. One interesting kind of starch, inulin, occurs in sweet potatoes and Jerusalem artichokes. It dissolves in water more readily than ordinary starch and does not give any color reaction with iodine. It hydrolyzes to fructose instead of maltose and is believed to have the formula



inulin unit

2.

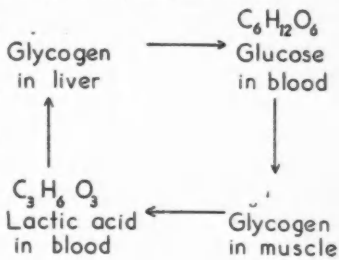
shown in the accompanying diagram.

Of more immediate interest is the animal starch, glycogen, whose formula must be similar to the conventional starches, for it hydrolyzes to glucose. With iodine it gives an indeterminate wine color, between red and purple, which can be seen by dropping tincture of iodine into a little water in which a bit of liver has been boiled.

The body maintains in the liver a considerable store of glycogen, which it makes out of the food it assimilates. The various complex steps by which these reactions occur are being studied actively at the present time. The recent discovery of radio-active isotopes of the common elements gives chemists the means of following individual atoms of carbon, hydrogen, phosphorus and the like through the body processes.

Carbohydrates are broken down, recombined and built up into starch-like units by fairly simple chemical processes. The intermediate steps in conversion of carbohydrates to fats and the reverse are not understood, although it is so well known as to be axiomatic that "starches are fattening." The steps in protein assimilation are even less clear, but apparently the nitrogen atoms are split off the molecule, the balance is turned into carbohydrate, and finally fat is formed from the carbohydrate.

Utilization of carbohydrate by the muscles has been worked out in considerable detail. Glucose seems to be the only form of carbohydrate which the body can utilize directly. Synthesis of glucose to glycogen consists of hooking up the simple rings of the sugar molecules to form the network of such structures which is characteristic of starch. This process, known as glycogenesis, is carried out in the liver. It also occurs in the muscles, where glycogen is formed from the sugar in the blood. Glycogen is broken down by muscle action into lactic acid. About one-fifth of the lactic acid seems to be further broken down to carbon dioxide and water, which are eliminated from the body. The other four-fifths is carried back by the blood to the liver, where it is re-synthesized to glycogen. The cycle may be diagrammed as shown.



3.

Body processes are never static. Radio-active material has shown the incessant building up, tearing down and shuffling around that the body chemicals undergo. The store of glycogen in the liver provides a reservoir of energy for sudden demands in emergencies. The mechanism for meeting these unusual demands is linked up with the interesting chem-

ical processes of ductless gland secretions.

Adrenalin from the suprarenal glands and insulin from the islands of Langerhans in the pancreas are available for study, and are found to operate against each other in one of those elaborate systems of checks and balances characteristic of the gland secretions. Failure of the body to produce enough insulin for normal carbohydrate metabolism results in the condition known as diabetes. Since the brilliant isolation of this secretion by the late Dr. Banting and his associates, much light has been thrown on this whole mechanism. The anterior lobe of the pituitary gland in the brain is known to play an important but imperfectly understood part in the process of sugar metabolism. This is one of the frontier fields in biological chemistry.

Soybean Equals Cottonseed Oil

➤ THE SOYBEAN is now Americanized, and soybean oil, its principal commercial product, is now manufactured in the United States in a quantity equal to that produced from cottonseed, which long was America's greatest source of edible oils. The soybean oil industry in America is only about two decades old, although imported soybean oil has been used for much longer than that. Wartime conditions greatly boosted production, but peacetime uses will probably keep up the present rate.

Soybean oil is used in the United States for shortening, margarine, other edible products, soap, paints and varnishes, linoleum and oilcloth, and in printing inks, but its principal use is in foods. Approximately 96% of the 1943 production was used in edible products, according to O. H. Alderks of the Soybean Research Council, reporting in Chemical and Engineering News, published by the American Chemical Society.

Some 891,000,000 pounds of soybean oil was used in 1943 in food products, he says. It has now replaced a great amount of cottonseed oil in shortening, the cottonseed oil having been shifted to other edible products. In margarine it has replaced all coconut, babassu and similar oils, and accounts for about 40% of margarine fats. In salads oils and cooking fats, 124,000,000 pounds were used in 1943, replacing the unobtainable coconut and palm oils of the Pacific area.

Soybean oil has a number of desirable qualities, Mr. Alderks states. It has generally low bleaching costs, whiter products, good rancidity behavior, and good consistency behavior. Its undesirable characteristics are poor flavor stability particularly of the lower-grade oils, and additional cost to hydrogenate.

Flavor stability will improve, according to Mr. Alderks, with an improvement in the entire soybean industry beginning with improved farm practices, better and quicker harvesting, prompt drying when necessary, better storage, and improved methods of oil extraction. Clean, fully matured, sound, fairly dry, yellow soybeans produce the best oil.

Radiant Heating for Passenger Aircraft

➤ Radiant heating, radiated from the walls, has entered the passenger airliner field to supply comfort to travellers. It is an entirely new system of heating and ventilating for these giant stratoliners, it is claimed. It is a system probably adaptable to home heating, although radiant heating from steam and hot water pipes is now in use in a thousand homes in the United States and in many factories.

Exact and continuous control of the circulated air in the giant planes, in flight and on the ground, is possible in the new system because of the combustion type heaters used that operate independently of the engines of the plane. They are the Janitrol type of heaters in which the gasoline fuel is injected into a whirling column of air enclosed in a cylindrical housing. Two such heaters are used in each plane, one alone being sufficient in ordinary temperatures.

Heated air from the heaters circulates between outer and inner walls of the plane, warming the walls and entering the passenger cabin near the roof. Impure air leaves the cabin under the seats. The Janitrol heater is a product made in Toledo, Ohio, by the Surface Combustion Corporation.

Hard Enamels

➤ More durable and sightly finishes for household refrigerators, stoves and other equipment is promised with new synthetic, exceptionally hard, stainproof enamels developed by the Arco Company and already in production. They will be known as synox finishes.

One type of the new enamel is designed for such articles as refrigerators, stoves, ironers and electric mixers, and another for dishwashers and washing machines. Laboratory and practical tests show that they have an unusual degree of water and alkali resistance, it is claimed, also resistance to stains and change of color.

The new material has been successfully applied to clean steel, with or without primer, and to aluminum and magnesium. Despite its hardness, synox has a flexibility which is more than ample to meet all service conditions.

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